Introduction

The U.S. Department of Energy's Rebuild America program fosters the formation of community and regional partnerships to renovate commercial and multifamily residential buildings. Specifically, Rebuild America both harnesses the capabilities of existing institutions, organizations, and programs, and encourages the creation of new institutions that can substantially improve building energy efficiency and promote community and regional development.

By stimulating local leadership and initiative, the program expects to launch hundreds of partnerships that will renovate thousands of commercial and multifamily residential buildings over the next several years. As a result, local communities throughout the United States will enjoy the associated benefits of energy-efficient buildings. These benefits potentially include increased economic activity, job creation, more affordable housing, cost savings, and a healthier environment, to name a few.

The purpose of this handbook is to guide you and your local community or regional group through the process of becoming a partner in the Rebuild America program and to help you plan and implement the energy retrofit of your local building stock. The handbook is organized into an eight-step process (see Figure 1) that is necessarily generic. Your partnership should customize the process as needed to meet the specific priorities and requirements of your buildings and community.

Although the eight process steps are discussed sequentially in this document, some may be conducted simultaneously in the interest of expediting the overall effort. Part of your team may begin investigating financing mechanisms (Step 4), for example, while another part begins collecting data (Step 2). Similarly, your team may elect to use commissioning services (discussed under Step 7) from the outset. For these reasons, if you and your team are not experts in the energy retrofit of buildings, you should become familiar with this entire handbook prior to beginning the process; those partners who are experts in energy retrofits will wish to focus on Chapters 1, 5, and 8, which contain information unique to the Rebuild America program.

To coordinate and implement the process, your partnership will need to assemble a strong energy management team. Although several knowledgeable members should remain on the energy management team throughout the entire process, the makeup of the team is likely to change with its different functions during the various stages of your

program. Initially, your team may be dedicated to determining the resources needed to accomplish local goals, identifying the available resources, and laying the foundation for future team responsibilities and structure. As technical work advances, people with different skills will be needed on the team to develop the plan, perform energy assessments, conduct audits of buildings, and to confirm the technical modifications and capital resources needed. As action progresses, the team will continue to evolve until the retrofits have been installed and a final team, capable of handling all ongoing tasks, is assembled.

As you and your team plan these analyses, keep in mind the possible need for staging your efforts; it may be necessary to conduct some initial testing of the recommended methods and procedures. For instance, if your team is uncertain of the issues involved in conducting

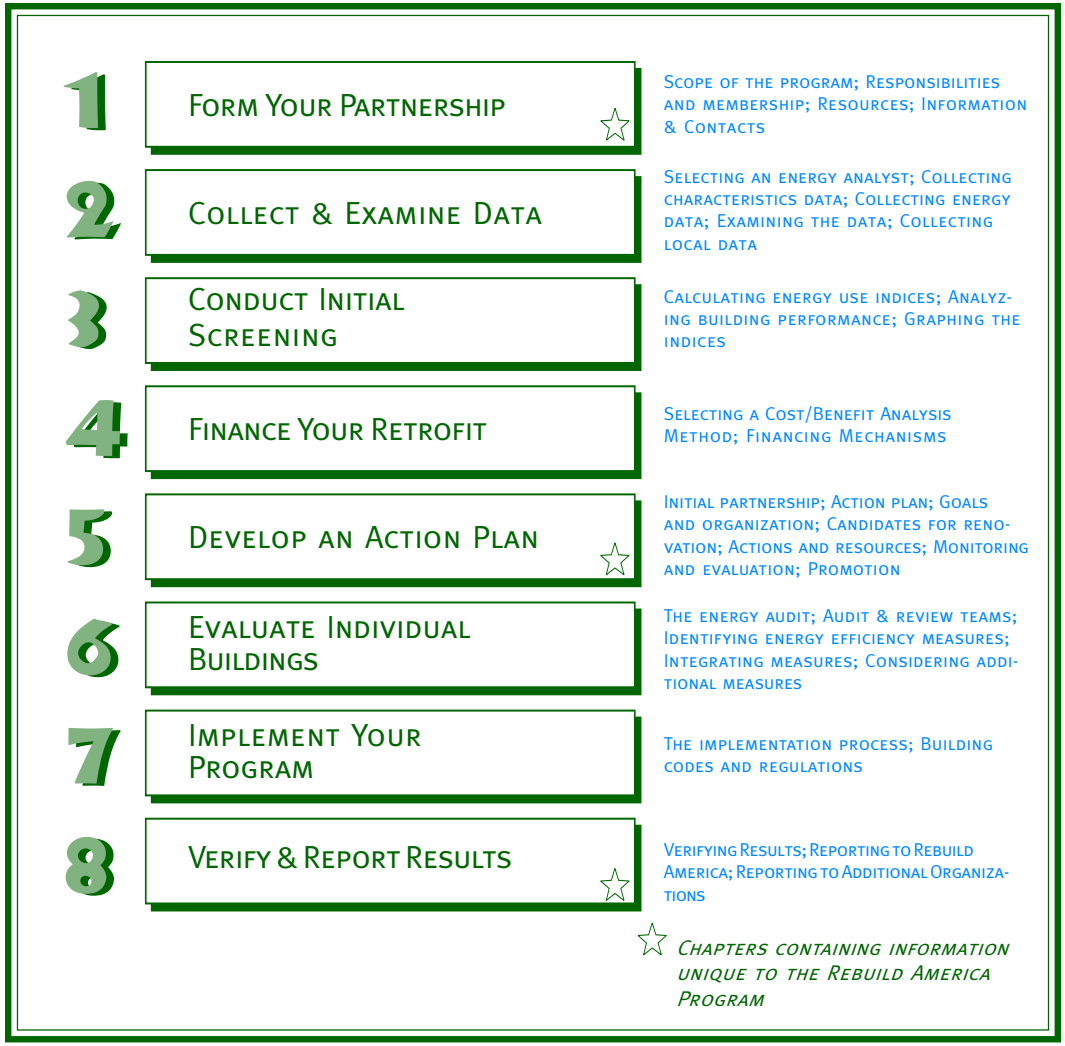


Figure 1. The Eight-Step Process

an analytical screening of your entire targeted building stock, you might first analyze a subset of the stock to develop a better understanding of the requirements. Similarly, if you are uncertain of the best approach for conducting energy audits, audits of just a few buildings may provide you with the knowledge you need to successfully scale up efforts to a larger number of buildings. The staging required for your particular program will depend on the mix of skills available on the team performing the analysis.

Additional information on any part of the energy retrofit process can be obtained from a variety of useful reference documents. Many of these are listed at the ends of the chapters along with the documents cited in the text. If you need assistance in obtaining specific reference documents, contact your assigned Rebuild America program representative. Lists of acronyms and units can be found at the back of this handbook along with information on how to contact the program.

How to Form Your Partnership

Through Rebuild America, local partnerships are formed to design and implement their own building renovation programs, tailoring them to the unique needs of their communities. The U.S. Department of Energy (DOE) may provide qualified partnerships with financial assistance or customized technical assistance, or both. Financial assistance received through this program may be applied to such activities as program administration, staffing, development of business and technical plans, evaluation of building energy use, and training, but not capital investments.

The Initial Partnership Step

To become a partner in the Rebuild America program, each prospective partnership must provide DOE with (1) a commitment that it intends to develop an Action Plan and (2) an identification of those organizations that will act together to develop the plan. Once this information has been received, DOE will assign your partnership a Rebuild America program representative, who will facilitate your access to written materials and other resources that can guide development of your plan. Generally, a partnership should expect to have its Action Plan completed within one year.

Responsibilities

Each partnership must be able to effectively plan, manage, finance, and implement energy-efficient retrofits in large numbers of commercial and multifamily buildings. Specifically, partnerships participating in Rebuild America will be responsible for conducting the following five activities:

Design Programs. Partners will design specific activities to either launch new, energy efficiency retrofit programs or significantly expand the reach and effectiveness of one or more existing programs.

Form Teams. Partnerships will solicit participation and commitments from key leaders of local government and industry and form teams to carry out the partnership programs.

Identify and Leverage Resources. Partnerships will identify and exploit resources available from private and public (both Federal and non-Federal) sources.

Implement Retrofits and Promote the Program. Partnerships will carry out retrofits that achieve significant energy savings in a large number of buildings and will market their successes to extend the reach and benefits of the program.

Verify and Report Energy Savings. Partnerships will track the energy impacts of building retrofits and report energy savings to Rebuild America.

Partnerships can evolve from existing or newly conceptualized energy programs and involve a variety of stakeholders.

All partnerships will also be encouraged to submit information on their successful local programs so that their efforts can serve as models of "best practices" for replication in other communities. The approach that each partnership intends to take in fulfilling these responsibilities will be described in their Action Plan and submitted to the Rebuild America program.

Membership

In forming a Rebuild America partnership, two or more organizations that already operate energy efficiency programs, or that are interested in creating one, must come together to combine and leverage their expertise and resources. The initial base for a partnership may consist of existing or newly conceptualized energy programs and should include a broad range of interested stakeholders.

To ensure strong local or regional leadership and focus, each partnership must include at least one representative of state or local government. In addition, partnerships may include energy utilities, economic development organizations, private businesses, technical experts, and others. In many cases, financial institutions can substantially augment a partnership's financial resources. Similarly, participation by private energy performance contractors or energy service companies (ESCos) can strengthen existing technical resources. Chapter 7 of this handbook addresses competitive solicitation and selection procedures to help ensure that your partnership will receive good value from such firms. Typical Rebuild America partners and their customary roles are shown in Table 1, while Federal Government partners and their roles are described in Table 2.

Resources

Partnerships are encouraged to make use of local resources throughout the entire program. Local experience and expertise will be particularly helpful in identifying and analyzing the best opportunities to improve energy efficiency and operations in your buildings. In addition, each partnership is responsible for identifying sufficient capital resources to implement the energy efficiency retrofits. A variety of capital resources and financing mechanisms are discussed in Chapter 4.

Table 1. Typical Rebuild America Partners and Suggested Roles

Partner	Implementation Roles
State and Local Government	▸ Participate directly as a leader or member of the partnership. ▸ Assist with publicity, briefings, and workshops to inform potential participants of the Rebuild America concept. ▸ Provide organizational assistance in the development, financing, and implementation of programs, and ensure coordination with other government agencies.
Utility Companies	▸ Participate directly as a leader or member of the partnership. ▸ Provide technical and financial resources (through rebates or other utility-sponsored incentives). ▸ Provide utility billing data to help identify candidate buildings and track energy savings. ▸ Assist with selection of efficiency measures.
Financial Institutions *May include local banks, energy service companies, real estate investment firms, and the like.*	▸ Directly finance (or provide assistance in financing) efficiency retrofit measures as part of a program partnership.
Business Leaders	▸ Participate and advise the partnership to ensure that the program designed is of value to corporate and private building owners. ▸ Help recruit others to join the program.
Educational Institutions *May include local universities, colleges, and vocational schools.*	▸ Participate directly in the partnership both to improve the efficiency of their own buildings and provide key resources for training of energy auditors, building operators, and trade personnel. ▸ They may also assist with collection, management, and analysis of the data required for program evaluation.
Building Owners, Managers, and Operators	▸ Identify candidate buildings for retrofit and assist in defining and carrying out capital investment strategies to implement the plan. ▸ Aid in tracking and assessing results to ensure competitive return on investments through reduced building energy costs.
Energy Service Companies	▸ Design and specify retrofit measures and/or install retrofit measures for buildings targeted by the partnership. ▸ In many cases, provide turnkey services that include financing for measures as well as continuing services for operations, maintenance, and monitoring.
Architects and Engineers	▸ Both provide and receive information and training as an active member of the partnership. ▸ Provide assistance in refining this information and training for additional applications.

Table 1 (cont.). Typical Rebuild America Partners and Suggested Roles

Partner	Implementation Roles
Architects and Engineers (cont.)	▸ Use and distribute energy efficiency retrofit tools. ▸ Design, specify, and inspect retrofit measures.
Builders, Remodelers, and Other Contractors	▸ Both provide and receive information and training as an active member of the partnership. ▸ Provide assistance in refining this information and training for additional applications. ▸ Use energy efficiency retrofit tools. ▸ Install retrofit measures.
Environmental and Energy Conservation Groups	▸ Participate in the planning of the local program, provide technical and financial assistance when available, and aid in the promotion of the program.
Other Community Organizations *Each community will have other partners appropriate to their local priorities.*	▸ Such organizations could include those addressing such related priorities as economic development, urban revitalization, historic preservation, or affordable housing.
Trade Associations *Includes associations representing any of the industry partners listed in this table (e.g., utility associations, associations of builders and remodelers, etc.).*	▸ Contribute to the development and refinement of the implementation plan. ▸ Develop and carry out training programs for members on the value of energy efficiency and improved retrofit techniques. ▸ Assist in the promotion of the program and increase awareness of energy-efficiency products. ▸ Provide leadership and improved financial mechanisms.
Equipment, Component, and Materials Vendors	▸ Both provide and receive information and training as an active member of the partnership. ▸ Provide assistance in refining this information and training for additional applications. ▸ Use and distribute energy efficiency retrofit tools. ▸ Assist in the design, specification, and installation of retrofit measures. ▸ Possibly provide financing for certain measures.

Table 2. Federal Government Partners and Their Roles

Federal Partner	Support Roles
EREC (Energy Efficiency and Renewable Energy Clearinghouse)	▸ Serve as a liaison for DOE on the Rebuild America program. ▸ Distribute program information, provide technical advice, and gather partnership results and "best practices" information to aid replication by other communities.
DOE Regional Field Offices	▸ Provide technical assistance and Rebuild America program information to individual partnerships. ▸ Selected staff from DOE Field Offices will serve as "Account Representatives" to individual partnerships.
DOE National Laboratories	▸ Provide technical assistance and training for partners and teams on the planning, design, financing, and monitoring of energy-efficiency measures.
DOE Headquarters	▸ Coordinate and fund the Rebuild America program from the national level. ▸ Develop and issue annual solicitations for financial assistance and customized technical support.

Information and Contacts

Parties interested in becoming Rebuild America partners can contact the Energy Efficiency and Renewable Energy Clearinghouse, also known as EREC. Contact information is provided on the back cover of this handbook. Alternatively, you or a partner who is a member of the building industry can contact your state energy office or local government agency to inquire about getting involved in the Rebuild America program.

2 How to Collect and Examine Your Data

Before you can begin your initial building analyses, you will need to collect some information about the energy use of your targeted building stock. At this stage, you should assemble an energy team, consisting of partners, industry experts, and other local participants, to collect and analyze the data or to oversee the process. Some partnerships may be fortunate enough to already have an energy analyst or other qualified individual on board to direct the data collection effort. If not, your partnership may want to hire one at this juncture. Alternatively, your energy team may opt to collect as much of the data as possible prior to hiring an expert. How you proceed will depend on the funds and expertise available to your partnership.

Whichever approach you decide to take, the information in this chapter is designed to guide you and your team through the process. If you have an analyst performing the work, the information provided will help you understand the objectives of the process so that you can assist in setting up the necessary contacts and make other contributions as appropriate. If you and your team are doing the work yourselves, the following outlined procedures will

Defining Your Building Stock

The process described in this handbook will help you to progressively narrow your focus from your entire building stock, or portion thereof, to the individual buildings that are likely to yield the greatest energy savings. The term "building stock" can mean different things to different partnerships. In this document, the following distinctions are made:

- Community Building Stock: All commercial and/or multifamily buildings in your community or under the jurisdiction of your partnership.
- Targeted Building Stock: The portion of your community building stock that your partnership will screen to determine the best candidates for energy savings.
- Candidate Buildings: The subset of the targeted stock that has passed the initial screening process and awaits further and more detailed energy and cost evaluation.
- Selected Buildings: The buildings selected to be the focus of your initial energy efficiency retrofits.

Your Rebuild America program representative can provide guidance on the range of buildings to be considered in each category.

serve as a starting point for your data collection efforts. As suggested in the Introduction, this document necessarily presents a generic approach to each step of the renovation process. Each partnership will find areas in which they need to augment or modify the generic approach to better address their particular situation. For those areas, you are referred to documents that cover specific cases or contingencies in greater detail. Bear in mind that much useful guidance will also come from your local agencies and organizations, local experts, and other local sources.

This chapter is designed to help you select an energy analyst and begin the collection and examination of data on your building stock. For those who are unfamiliar with utility practices and rate schedules, brief explanations and definitions are provided. Particular emphasis should be placed on ensuring the accuracy of the data elements, since they will provide the basis for significant financial investment decisions. The final subsection in this chapter discusses the advisability of collecting local or regional energy performance data as an alternative to the national energy use indices presented in the next chapter.

Selecting an Energy Analyst

People skilled at analyzing energy use in the particular types of buildings in your stock can assist your team in selecting the buildings that represent the best opportunities for savings. Finding a skilled analyst or analytical group is an integral part of finding the good opportunities. In choosing an analyst, you will want to look for the following qualifications:

- Building energy survey skills. The analyst should be experienced in using a light meter and other devices for performing initial on-site testing of a building's current energy use characteristics. Such surveys are intended to quickly identify buildings that are potentially large consumers of energy; accordingly, analysts do not necessarily need the full set of skills used by energy auditors (discussed in Chapter 6).

- Data Collection experience. The individual should have demonstrated experience in collecting buildings characteristics and energy data from utilities, using floor plans, developing occupant questionnaires, conducting building owner/operator phone interviews, and so forth.

- Building energy analysis expertise. The analyst should be experienced with methods for analyzing energy savings from retrofits and methods for assessing the relative energy efficiency of buildings. He or she should also be familiar with methods for handling utility-metered data, familiar with building energy metering methods, knowledgeable about how energy is used in different types of buildings, and skilled at identifying

the buildings that are the best candidates for energy efficiency measures.

- Communication and computer skills. These skills should include the ability to handle data archives and provide backup, the ability to handle large data files, familiarity with data processing software (if a large number of buildings are to be analyzed), and the ability to generate useful reports and presentations.

A qualified energy analyst or analytical group can be identified through local business directories and associations or by consulting local utilities, government energy agencies, and architects. Engineering firms also provide such services or can direct you to local experts.

Collecting Building Characteristics Data

Your first data collection task involves the gathering of building characteristics data for your building stock. These data items describe the nature and size of each targeted building and are essential to the correct interpretation of the energy data. Of the top five building data elements shown in the box on the following page, the first two are needed for each multifamily building and the last four are needed for each commercial building. All of these items should be relatively easy to obtain.

Floor-area values are often available from the property or lease records. Such values are likely to be based on usable conditioned floor area. Insurance and construction costs are generally estimated on the basis of gross floor area, which is the total floor area on all levels of a building measured from the outside surface of the walls (or from the centerline of walls of attached buildings). Other methods of measurement may also be used; the important thing is to use a consistent set of floor-area data for your building stock.

Remain consistent in the way you measure floor area throughout your building stock.

The additional building data elements shown in the box will typically be needed for later use in the evaluation of individual buildings. If these data elements are readily available, it may be best to collect them now, along with the required data. If they are difficult to obtain, you may wish to wait until after the initial analysis, when the focus is likely to be on a smaller number of buildings.

Collecting Energy Data

For each building in the stock targeted by your partnership, you will also need to collect energy data. A minimum of one year of monthly data is required for the basic analysis of your targeted building stock, but two years of data are more desirable since that is the amount needed to perform certain graphical analyses. The specific data elements that need to be collected for each

Building Characteristics Data Elements

Needed

- Number of dwelling units in multifamily buildings (and square footage of a typical unit, if available)
- Building type and use (i.e., principal building activity)
- Total square footage of the floor area included in commercial buildings
- Type of square footage (e.g., gross, net rentable, net usable, etc.)
- Hours of occupancy for commercial buildings—the actual amount of time that the building is used on a monthly basis (the hours of business operation plus any additional hours in which significant occupant activity occurs)

Additional

- Ownership/occupancy (It may be useful to know who occupies a building when comparing it to other candidate buildings. Owner-occupants have the greatest incentive to implement energy-saving measures)
- Building age
- Plans and specifications (The team should try to obtain "as-built" plans and specifications from the building owner or manager. If not available, single-line diagrams will need to be drawn to indicate the equipment in place, connected loads, and other major features)
- Types of renovations previously performed
- Energy system operation and maintenance (O&M) practices (If available, O&M logs and equipment manuals help indicate how equipment is being operated and maintained and how changes in O&M routines may have affected equipment performance. Valid warranties and guarantees on equipment that may be modified could also be useful)
- Heating and cooling fuels
- Type of control system
- Types of lighting (by percentage of floorspace)
- Type of heating/cooling system
- Extent of computer use by occupants (general types and estimated quantities)

Energy Data Elements

Electric

- Building Identification—as determined by utility account number, meter location, and/or customer name
- Meter Number
- Billing Start and End Dates
- Monthly Total Electrical Consumption (in kWh)
- Monthly Peak Electrical Demand (in kW, if available from the utility)
- Monthly Total Electrical Cost (in $)
- Rate Schedule Identification

Optional data elements that may also prove useful include the following:

- Monthly Electrical Off-Peak Consumption (kWh/month)—may not be used by the utility directly, but may be available through 15-minute demand data for off-peak hours
- Monthly Electrical On-Peak Consumption (kWh/month)—may not be used by the utility
- Contract Demand (in kW)
- Average Electric Consumption Unit Cost (in $/kWh)
- Average Electric Demand Unit Cost (in $/kW)

Gas

- Building Identification
- Meter Number
- Billing Start and End Dates
- Monthly Natural Gas Consumption (in kBtu)—if gas consumption is reported in other units, it should be converted to kBtu; refer to Appendix A
- Monthly Natural Gas Cost (in $)
- Rate Schedule Identification

Optional data elements that may also prove useful include the following:

- Average Gas Consumption Unit Cost (in kBtu)
- Monthly Peak Gas Demand (in kBtu/day)

Other Fuels

- Similar data can also be collected for fuel oil, propane, coal, purchased steam, and chilled water, if applicable to your building stock.

building are listed in the box on the previous page. Those elements that are not self-explanatory are discussed later in this chapter. If you need to convert your data to the units indicated in this list, you may want to use the unit conversions table provided in Appendix A. The best source for energy data is usually the utility or utilities providing energy services to the buildings under consideration. If the data elements you want are not already available from past utility bills, they may be obtained through your utility account representative. Some utilities also offer a range of programs and services, from energy audits to rebates or financing programs for the installation of energy-efficient equipment. You will find it useful to establish a continuing working relationship with your utility account representative and to understand the conditions and costs of the services provided.

Requesting Data from Utilities

Upon request, utilities can provide their customers with data on energy consumption in their buildings. These data are usually available in a format similar to that of monthly energy bills and cover a period of 12 to 24 months (or billing cycles) prior to the date of inquiry. If different fuels are provided by more than one utility, consumption data should be gathered from each company.

Some utilities will require a written request (including authorization from the building owners) before they will release the appropriate data (see sample letter in Figure 2). In order to ensure a prompt and thorough response, experience shows that during the initial contact, both the requester and the supplier of building energy information should have top-level authority in their respective organizations. For example, the mayor or his or her immediate assistant might make the first contact with the utility's general manager to explain the need to quantify energy consumption by the targeted building stock and request cooperation on the project. Upon agreement, contacts should be set up within both organizations to handle the transfer of energy data.

Data may be requested in several formats, although an electronic format is the most efficient. Plain-text versions of the data (sometimes called ASCII) are often the easiest to transfer from one computer to another, but you will want to make certain that the format you request can be read easily on your own computer. Since many utilities maintain archival data on mainframe computers, you may have to arrange for the data to be transferred from tapes to diskettes. At a minimum, you will want to request data for the most recent 12 months or billing periods and, if possible, you should obtain 18 to 24 months of data to support further analyses.

Typically, you will need to confirm the account numbers and service addresses of the targeted buildings. It may be difficult to match utility meters with their correct buildings and accounts and to verify which buildings are metered,

Date

Ms./Mr._____
Utility Engineer
City of _____
Address

City, State Zip

Dear _____:

RE: REQUEST FOR BILLING INFORMATION

I enjoyed the opportunity to speak with you on August 5 and appreciate your willingness to provide the electrical billing history and related information for our analysis. Signed authorizations from the building owners are enclosed. We are requesting the following data for all facilities shown on the attached list for the period of January 1, 1994, through the most recent billing:

- service address;
- account address, if different than service address;
- account name;
- account number;
- meter number;
- beginning and ending dates for each billing period;
- meter reading or total kWh for each billing period;
- peak demand (in kW);
- total charges, minus special service fees, for each billing period;
- applicable rate schedule;
- off-peak consumption (kWh) for each billing period (if applicable); and
- on-peak consumption (kW) for each billing period (if applicable).

Thank you for your cooperation in supplying us with the billing records for these facilities. It would be helpful if we were to receive the information by the end of August. If you have questions regarding my requests, please do not hesitate to call me.

Sincerely yours,

Enclosure

Figure 2. Sample Letter Requesting Data from Utility

but these steps are necessary to confirm the results of any efficiency improvement efforts. Since some buildings may be served by more than one meter, steps should be taken to ensure that no meter is counted twice or omitted altogether. Your utility account representative should be able to assist you in locating and identifying service locations and account numbers.

Understanding Your Utility Bill

Although a utility bill usually covers a single building, other arrangements are not uncommon. Large installations, such as military bases or educational facilities, generally have electric power provided to a few locations or to a substation. From a substation, the power is distributed to end-users by way of a facility-owned transmission and distribution system. In such situations, end-users may have installed their own submetering devices to track energy use by building or other functional area.

For each metered service delivery point, utilities generally send out monthly statements. Each statement covers a billing cycle (typically between 20 and 40 days) and provides information such as the meter number, present and previous readings, monthly consumption, peak demand, and the total monthly cost to the customer. The utility bill, in conjunction with the rate schedule and applicable riders, should provide sufficient information for your team to recalculate the bill and ensure that it is accurate, if warranted.

Rate Schedules. Monthly bills are based on utility rate schedules corresponding to the class of service received by the customer. The rate schedule is a contract between the utility and the customer and includes provisions regarding the availability, applicability, and character of the service; a breakdown of rate charges; operating procedures; minimum billing charges; and terms and conditions for providing service. Several different rate schedules are available from the utilities, which do their best to match the needs of the customer to the most reliable and economical class of service.

Utility rate schedules may vary among utilities and even among buildings served by the same utility. As a rule, the electric utility rate schedules tend to be more complex than gas rate schedules. If you have any questions about your local rate schedule, you should direct them to your utility account representative. The same individual should be able to help you identify the specific rate schedules for your building stock and determine the cost benefits of many potential retrofit activities.

Rate schedules are primarily based on energy consumption and demand. These key factors are discussed below, while other terms typically found in electric and gas rate schedules are defined in Figures 3 and 4, respectively.

Electrical Consumption. The cost for direct consumption is based on a $/kWh charge, and may be adjusted seasonally. Other direct and indirect consumption charges such as the Fuel Cost Adjustment, the Purchased Power Cost Recovery Factor, and the Cogeneration Power Cost (as defined in Figure 3) may not always appear on the monthly utility bill, or may, for simplicity, be incorporated into the overall cost for consumption. The time of day of consumption may also influence utility costs: some electric utilities divide total consumption into peak and off-peak components and charge accordingly. Peak supply hours for a utility generally occur between the hours of 8 a.m. and 9 p.m., and the cost of energy to consumers during this time may be nearly double the off-peak cost.

Electrical Demand. Demand charges are also significant and should be clearly understood. Electrical demand is defined as the instantaneous need for electrical energy, or the rate at which energy is consumed, in kW. Demand costs are based on a $/kW charge. The monthly peak demand is the highest demand level recorded, in time increments of 15 or

Cogeneration Power Cost: Costs passed on to the customer for power purchased by the utility from cogenerators in $/kWh-mo.

Contract Demand: Power level that the utility guarantees to supply to the building, usually the maximum demand level required for a building to operate.

Demand Charge: A charge for the maximum rate at which electricity is used during peak hours of the billing period (Peak Demand), in $/kW-mo. May also have reduced charges for off-peak demand.

Energy Charge: A charge for the amount of electricity used in the billing period, in $/kWh-mo. May be separated into peak- and off-peak components of consumption and may vary seasonally.

Fuel Cost Adjustment, or FCA: Consumption cost adjustment used to reflect the varying market value of fuel, in $/kWh-mo.

Late Charge: A fee applied to the entire monthly balance for overdue payment, usually 5% of the total monthly bill, in $.

Peak Hours: Daily operating hours during which the highest level of demand for electricity from the utility exists. Electricity costs during these hours may be higher as the utility tries to encourage customers to reduce their demand.

Power Factor Charge: Penalty applied to the monthly peak demand when the ratio of the actual rate of energy used by the building equipment (kW) over the rate of energy supplied by the utility (kVA), is less than 85%.

Purchased Power Cost Recovery Factor: Costs passed on to the customer for power purchased by the utility from other suppliers, in $/kWh-mo.

Ratchet Clause: Penalty for an unusually high monthly peak demand. The ratchet demand will replace actual demand levels on bills for 12 months following the peaking incident.

Sales Tax: Tariff based on amount of energy consumed, in $/kWh-mo.

Service Charge: An administrative charge fixed at a small flat rate, based on services provided.

Figure 3. Terminology in a Typical Electricity Rate Schedule

Allocation Charge: Charge for consumption in excess of monthly gas allocation as defined in the service contract, in $/CCF-mo or $/tTherm-mo. Usually only applied to larger customers.

Contract Demand: Maximum daily amount of gas that utility agrees to supply to the building, usually the maximum daily amount of gas that a building requires to operate.

Demand Charge: A charge for the maximum daily consumption of gas during the billing period, in $/$CCF_{DAY}$ or $/$therm_{DAY}$.

Energy Charge: A charge for the amount of gas consumed during the billing period, in $/CCF-mo or $/therm-mo. This charge may fluctuate seasonally.

Late Charge: A fee applied to the entire monthly balance for overdue payment, usually 5% of the total monthly bill, in dollars.

Pipeline Charge: Utility costs for rental of pipeline space and recovery fees for financial losses resulting from deregulation, $/CCF-mo or $/therm-mo.

Purchase Gas Cost Adjustment: Costs passed on to the customer that reflect the fluctuations in the market value of gas, in $/CCF-mo or $/therm-mo.

Ratchet Clause: Penalty for an unusually high monthly demand. The ratchet demand will replace the actual demand levels on bills for 12 months following the peaking incident.

Sales Tax: Tariff based on amount of gas consumed, in $/CCF-mo or $/therm-mo.

Service Charge: An administration charge fixed at a small flat rate, based on services provided, in dollars.

Figure 4. Terminology in a Typical Gas Rate Schedule

30 minutes, during the peak supply hours for the utility. Often, through a Ratchet Clause, utilities will penalize an unusually high monthly peak demand by applying that demand to the rate structure for 12 months after it occurs. Additional demand charges are applied when the building experiences a low Power Factor. This occurs when equipment, such as fan motors and lights, demands more electric current from the utility than it actually needs to operate.

Gas Consumption and Demand. Gas utility rate schedules tend to involve fewer factors. Consumption charges will be found in all rate schedules, while demand charges may only apply to larger customers. Monthly consumption charges are applied in $/CCF, or $/therm, and may be adjusted seasonally. Demand charges are applied in dollars per maximum daily demand for the billing period, or $/$CCF_{DAY}$ or $/$therm_{DAY}$. As with electrical demand charges, they may be subject to a Ratchet Clause. The Purchased Gas Cost Adjustment modifies monthly rates in response to changes in how much it costs the utility to purchase the gas. Finally, rental costs for pipeline space and pipeline recovery costs resulting from deregulation are incorporated into a Pipeline Charge.

A review of utility bills can be helpful in identifying potential opportunities for energy efficiency and associated cost reductions. Billing information can help determine (1) if power-factor correction is required (consult your local utility for solutions), (2) if power consumption could be rescheduled to off-peak periods, and (3) if there are suspect trends in energy demand and usage. A review of billing data might also indicate the potential for shifting to more economical rate schedules, depending on the nature of monthly energy use.

Examining the Energy Data

Although utilities are generally reliable in reporting data, steps should be taken to understand and verify all values. Occasionally, meters may be misread or misreported, or may even be broken. Identifying these instances as they occur could lead to substantial monetary savings. For this and other reasons, it is a good idea to continue your data collection and verification efforts throughout the retrofit program and on a continuing basis thereafter. Procedures for establishing an ongoing monitoring program to augment utility data are discussed in Appendix B.

The data you collect will help to validate the savings achieved and facilitate rapid identification of any potential energy problems. In examining energy consumption data, remember to do the following:

- Confirm that the number of utility accounts collected corresponds to the number of meters available at each site.

- Determine how utility account data should be combined or separated to represent buildings, clusters of buildings, or portions of buildings, and match the resulting energy use data to the appropriate floor area data. This is not necessarily an easy task, but technical assistance is available through the Rebuild America program.

- Examine the data to look for any months with unusually high or low levels of consumption or demand. If unusual months are found, consult with building occupants, equipment operators, repair people, and your utility representative to account for the unusual consumption or demand.

- Take steps to correct any data believed to be erroneous. Where correction is not possible, keep track of the particular data element so that it does not inappropriately impact your assessment of building performance (e.g., when comparing building data to national statistics or graphing the data).

- In analyzing energy use patterns, remember that the amount of energy a building consumes can be substantially affected by weather conditions. Your energy team may want to obtain weather data for each year of energy data collected. Such data is usually available from the local utility, but may also be obtained from the National Climatic Center, Federal Building, Asheville, NC 28841. Weather adjustments can improve the results of energy analyses from buildings, but this type of analysis can also be expensive and time consuming. Your Rebuild America representative can help you with such adjustments, if needed.

Verification of energy use data is not a trivial task, but is crucial to the overall effort to improve energy efficiency. Knowledge of local utility rate schedules and energy use patterns will be particularly helpful.

Collecting Local Energy Data

The next chapter will show you how to use your building characteristics and energy data to construct energy use indices. These indices can then be compared with the "average" indices of similar buildings to help you gauge the energy performance of your buildings. Although national average indices are provided in this document for your convenience, it would be preferable to compare your indices to those of similar buildings within your local area or region.

You and your team are encouraged to seek out and obtain energy performance data (including building type, fuel type, consumption, and demand) for selected buildings within your locality, municipality, or region. Possible sources

of local average indices (perhaps even by principal building type) include local utilities, your state energy office, and other local or regional energy agencies. Alternatively, you and your team could use the method presented in the next chapter to develop your own local benchmarks: energy use indices for your entire community building stock or some subset thereof (e.g., those buildings built or renovated recently and considered to be energy efficient).

References

Gillman R.A., J.E. Patton, W.F. Sandusky, and S.G. Hauser. 1989. Experiences with a Large Load Research Project in the Pacific Northwest: ELCAP. *Proceedings of End-Use Load Information and Application Conference in Syracuse*, NY, May 16-17. (Available from SAIC/Fleming in Syracuse, NY.)

GSA. 1994. *Energy Management: A Program to Reduce Cost and Protect the Environment.* U.S. General Services Administration and the Electrification Council (Available through the Electrification Council at 202-508-5900).

NECA and EEI. 1993. *Energy for the Year 2000: A Total Energy Management Handbook.* Washington, DC: National Electrical Contractors Association and the Edison Electric Institute. (Available through the NECA Publications Department at 301-657-3110.)

PNL. 1993. *Utility Management Handbook.* Richland, WA: Pacific Northwest National Laboratory for the U.S. Army Forces Command. (Available through Doug Dixon of PNL at 509-372-4253.)

3 How to Conduct an Initial Screening

To get the most out of energy efficiency investments, your energy team should conduct an initial analysis of the targeted building stock to identify the best opportunities for energy savings (before any detailed, on-site energy audits or studies are conducted). Good analysis work at this stage will also help your team to formulate initial estimates of potential energy savings and to manage its efforts effectively.

This chapter explains how to develop energy use indices and then apply them to evaluate building performance. Two evaluation methods are explained: (1) comparison to national "average" indices and (2) graphing of average indices over time. The first method requires a relatively small amount of data and provides a quick way to gain a basic understanding of energy use in your building stock. The second method requires more data but provides a better picture of energy use patterns. Since interpretation of the results can become complicated, you should have an energy analyst or other qualified professional involved in this phase of the analysis. Whenever possible, you are strongly encouraged to seek out local experts; local, energy-related building data; and other local resources to aid in the interpretation of your data.

Focus on "Energy Hogs"

In planning the initial analysis efforts, bear in mind that energy efficiency for a group of buildings can be heavily influenced by just a few of the largest energy users in the group. For instance, you may find that in a group of 100 buildings, just 10 of those buildings are responsible for 80% of all the energy used by the group. In that event, an average savings of 30% achieved in just those 10 buildings would mean a 24% savings for the entire stock (0.30 x 0.80 = 0.24). Clearly, the buildings with the highest energy use can greatly influence your overall results and should receive the most attention. As discussed in the next chapter, focusing your efforts on a limited number of buildings with high energy use could also help lower the total costs for your program.

Calculating Energy Use Indices

Note: All equations for calculating energy use indices are shown on pages 26-27.

Energy use indices (EUIs) combine building characteristics with energy data to provide a simple benchmark for evaluating the energy performance of buildings. In addition to targeting energy-saving opportunities, EUIs may help you identify problems that exist in specific buildings, such as unnecessary after-hours use of lights or mechanical systems, inefficiencies with lighting and other building systems, or excessive infiltration of outdoor air into conditioned spaces.

Your team may find it useful to calculate energy use indices on a monthly basis and record them using a computer program (such as a spreadsheet) to track energy use over a period of time. The worksheet format provided later in this section can be used to record key building characteristics and utility data on your computer and for calculating EUIs automatically. In this manner, consumption and demand indices may be compared each month on a continuing basis to help clarify how a building is using energy. Similarly, load factors (explained below) can be used on a monthly basis to investigate sources of excessive consumption or demand without much additional effort.

Storing the data on computer will also make it relatively quick and easy to compare indices accurately and examine them graphically for each month. For example, many computer spreadsheet programs available today have built-in graphing routines. If you are analyzing a large number of buildings, however, database or statistical programs may be necessary.

This chapter provides definitions and applications for a variety of useful indices, namely the Electrical Consumption Index, Electrical Peak Demand Index, Electrical Load Factor, Electrical Occupancy Load Factor, and the Natural Gas Consumption Index. The remainder of this section explains their use and interpretation. Although this section addresses only the more common energy sources of electricity and natural gas, the methodology given here can also be used to calculate indices for fuel oil, propane, coal, and purchased steam.

Electrical Consumption Index

The monthly and annual electrical consumption indices, shown in Equations 1 through 3 on page 26, are calculated in terms of kilowatt-hours per square foot (kWh/ft^2). Since multifamily building energy use is generally considered to be more accurately represented on a per unit or per household basis, however, you may elect to perform your calculations for residential buildings in that way. Keep in mind that most utilities use billing cycles or periods that are only approximately one month in length. As a result, the sum of 12 consecutive billing cycles could, in fact, equal 373 days or 352 days. The equations below take these cycles into account and adjust the billing data to reflect monthly and annual equivalents.

Equation 1 can be used to calculate a building's consumption index (or intensity) for a given month. When calculated for every month in the previous year, this traditional approach allows you to identify seasonal energy use trends (including baseline energy use during mild months) as well as abnormal energy use patterns within a building. The drawback to this index is that it cannot be easily compared to average consumption data for other, similar buildings. An alternative approach is described next.

Both Equations 2 and 3 represent the annual electrical energy consumption intensity for a building, although one is based on annual data and the other on monthly. The index based on annual data is straightforward. It is simply the sum of a building's electricity use over 12 consecutive billing periods (normalized to a 365-day year) divided by the building's floorspace. In comparison, the index based on monthly data is calculated by taking the consumption for a given month and multiplying it by approximately 12 (365 days divided by the number of days in the monthly billing period) to obtain an annual equivalent, which can be compared to average annual consumption indices like those in Table 3.

This annualized index can help to identify energy situations that might not otherwise be evident. For example, it may be used to spot a building with average annual energy use but with abnormally high monthly consumption for one or more months when compared to national or local building stock "averages". (An example is provided in the following section, Applying the Indices to Analyze Building Performance.) You should therefore calculate and compare an annualized index for each month of a full year.

Electrical Peak Demand Index

The monthly and annual electrical peak demand indices, which are reported in Watts per square foot (W/ft^2), are calculated as shown in Equations 4 and 5. If peak demand indices are high for several months within a year, the potential exists to reduce this peak demand.

Electrical Load Factor

The monthly and annual electrical load factors (ELFs), which measure how a building uses its entire inventory of electrical equipment, are computed using Equations 6 and 7. Basically, the ELF is the ratio between the average load (electrical power used) over a period and the peak load for that period. Smaller ELFs (<0.15) are indicators of spiky profiles, which may indicate that there are high, short-lived peaks in demand for electricity by the building equipment. Utilities often impose financial penalties for high monthly demand spikes for up to a full year following the peak. It is therefore advantageous to monitor and react to low ELFs, if possible, on a monthly basis.

Be aware of the distinctions between monthly, annual, and "annualized" indices.

EQUATION 1

$$\text{Monthly Electrical Consumption Index } (kWh/ft^2 \cdot mon) = \frac{\text{Monthly kWh x 30 days/month}}{\text{Floor area } (ft^2) \text{ x \#-days in monthly billing period}}$$

EQUATION 2

$$\text{Annual Electrical Consumption Index } (kWh/ft^2 \cdot yr) = \frac{\text{12-month total kWh x 365 days/year}}{\text{Floor area } (ft^2) \text{ x \#-days in 12 monthly billing periods}}$$

EQUATION 3

$$\text{"Annualized" Electrical Consumption Index } (kWh/ft^2 \cdot yr) \text{ (monthly basis)} = \frac{\text{Monthly kWh x 365 days/year}}{\text{Floor area } (ft^2) \text{ x \#-days in monthly billing period}}$$

NOTE: IF CONSUMPTION IS DIVIDED INTO PEAK AND OFF-PEAK PERIODS, COMBINE THESE INTO A TOTAL CONSUMPTION FOR THE PERIOD (MONTH OR YEAR).

EQUATION 4

$$\text{Monthly Demand } (W/ft^2) = \frac{\text{Peak monthly kW}}{\text{Floor area } (ft^2) \text{ X 1000 W/kW}}$$

EQUATION 5

$$\text{Annual Demand } (W/ft^2) = \frac{\text{Peak Annual kW}}{\text{Floor Area } (ft^2) \text{ x 1000 W/kW}}$$

EQUATION 6

$$\text{Monthly ELF} = \frac{\text{Monthly kWh}}{\text{Peak monthly kW x total billing hours for the month}}$$

EQUATION 7

$$\text{Annual ELF} = \frac{\text{Annual kWh}}{\text{Peak annual kW x total billing period hours for the year}}$$

NOTE: TOTAL HOURS IN BILLING PERIOD = NUMBER OF DAYS IN BILLING PERIOD X 24 HOURS PER DAY.

Electrical Occupancy Load Factor

Monthly and annual electrical occupancy load factors (EOLFs) are indicators of after-hours energy consumption in a building and are calculated as shown in Equations 8 and 9. For buildings with standard business operating hours, excessive after-hours consumption is usually unnecessary. If electrical consumption is separated into peak and off-peak components, your analyst can confirm high EOLFs by examining the off-peak data. As a rule of thumb, if the EOLF is close to or greater than 1.0, needless after-hours consumption probably exists in the building. If monthly EOLFs are greater than 1.0 for several months, the potential exists for saving energy by ceasing unnecessary after-hours consumption.

Natural Gas Consumption Index

Monthly, annual, and "annualized" natural gas indices represent the natural gas consumption for a building and are

$$\text{Monthly EOLF} = \frac{\text{Monthly kWh}}{\text{Peak monthly kW x } \textit{occupied} \text{ hours in monthly billing periods}}$$

Equation 8

$$\text{Annual EOLF} = \frac{\text{Annual kWh}}{\text{Peak annual kW x annual } \textit{occupied} \text{ hours}}$$

Equation 9

$$\text{Monthly Gas Consumption Index (kBtu/ft}^2 \bullet \text{mon)} = \frac{\text{Monthly kBtu x 30 days/month}}{\text{Floor area (ft}^2\text{) x \#-days in monthly billing period}}$$

Equation 10

$$\text{Annual Gas Consumption Index (kBtu/ft}^2 \bullet \text{yr)} = \frac{\text{12-month total kBtu x 365 days/year}}{\text{Floor area (ft}^2\text{) x \#-days in 12 monthly billing periods}}$$

Equation 11

$$\text{"Annualized" Gas Consumption Index (kBtu/ft}^2 \bullet \text{yr) (monthly basis)} = \frac{\text{Monthly kBtu x 365 days/year}}{\text{Floor area (ft}^2\text{) x \#-days in monthly billing period}}$$

Equation 12

calculated in thousand of Btus per square foot of floorspace (kBtu/ft^2) as shown in Equations 10 through 12. If your gas consumption data are in units other than kBtu (kBtu = 1,000 Btu), they should be converted using Appendix A. Refer back to the subsection on the Electrical Consumption Index for a discussion on "annualized" monthly indices.

Energy Use Index Worksheet

In organizing your data and calculating the indices, you may find it helpful to develop a worksheet similar to that shown in Figure 5. This energy use index worksheet is applicable to most buildings using electricity and natural gas. The worksheet also includes space for a third fuel type (e.g., fuel oil, propane, purchased steam, etc.). If additional fuels or fuel charges apply to a particular building, you can either convert unused columns or add new ones. A separate sheet should be used for each building and year of data. As suggested earlier, your energy team may wish to computerize this worksheet using an electronic spreadsheet or customized database program.

Applying the Indices to Analyze Building Performance

After your team has calculated energy use indices, the values can be compared with existing annual building stock EUI data as a first step toward identifying those buildings with the best potential for energy retrofits. Tables 3 through 5, which are based on large, statistically significant samplings of buildings across the country, are provided for this purpose. To identify unusually high annual consumption, the EUIs computed in Equations 2, 5, 7, 9, and 11 should be compared to these tables, according to the appropriate building and fuel type. To identify unusually high monthly consumption, the EUIs calculated for each month of the year using Equations 3, 4, 6, 8, and 12 should be used for comparison. EUIs for commercial buildings that use either electricity or natural gas may be looked up by building function in Tables 3 and 4.

The EUIs provided in Tables 3 and 4 are disaggregated into "low," "mid," and "high" categories of consumption intensity. When comparing your building EUIs to the data in these tables, select the appropriate category based on the intensity of each building's loads and the climate in your area. For example, if a building is dominated by computer facilities or heated electrically, consider comparing that building to the national electrical EUIs in the "high"

Energy Use Index Worksheet

Year: _____

Building Identification: _____

Building Type/Principal Activity: _____

Total Floorspace (1)*: _____ (square feet; generally applies only to commercial buildings)

Type of Commercial Square Feet: _____ (gross, net usable, net rentable, etc.)

Number of Housing Units (1)*: _____ (applies only to multifamily buildings)

Month (2)	Occupied Hours (3)	Electricity								
		# Days in Billing Period (4)	Total Consumption (kWh) (5)	Demand (kW) (6)	Total Cost ($) (7)	Monthly/Annual Consumption EUI (kWh/ft²) (A)	Annualized Consumption EUI (kWh/ft²) (B)	Demand (W/ft2) (C)	ELF (D)	EOLF (E)
January										
February										
March										
April										
May										
June										
July										
August										
September										
October										
November										
December										
Annual Total										

** For multifamily buildings, EUIs can be expressed on "per unit" or "per square foot" basis; the former is generally preferred.*

Calculations (use unit conversions in Appendix A if necessary):

A - monthly: (Column 5 x 30 days/month) / (Item 1 x Column 4) or Equation 1

A - annual: (Sum of Column 5 x 365 days/year) / (Item 1 x Sum of Column 4) or Equation 2

B - annualized: (Column 5 x 365 days/year) / (Item 1 x Column 4) or Equation 3

C - monthly: (Column 6 x 1000 W/kW) / (Item 1) or Equation 4

C - annual: (Highest monthly demand level in Column 6 x 1000 W/kW) / (Item 1) or Equation 5

D - monthly: (Column 5) / (Column 6 x Column 4 x 24 hours/day) or Equation 6

D - annual: (Sum of Column 5) / (Annual demand in Column 6 x Sum of Column 4 x 24 hours/day) or Equation 7

E - monthly: (Column 5) / (Column 6 x Column 3) or Equation 8

E - annual: (Sum of Column 5) / (Annual demand in Column 6 x Sum of Column 3) or Equation 9

Figure 5. Energy Use Index Worksheet

Energy Use Index Worksheet (continued)

Total Floorspace (1)*: _____ (square feet; generally applies only to commercial buildings)
Number of Housing Units (1)*: _____ (applies only to multifamily buildings)

	Natural Gas					Other Fuel Type: _____				
Month (2)	# Days in Billing Period (8)	Total Consumption (kBtu) (9)	Total Cost ($) (10)	Monthly/Annual Consumption EUI (kBtu/ft²) (F)	Annualized Consumption EUI (kBtu/ft²) (G)	# Days in Billing Period (8)	Total Consumption (kBtu) (9)	Monthly/Annual Total Cost ($) (10)	Consumption EUI (kBtu/ft²) (F)	Annualized Consumption EUI (kBtu/ft²) (G)
January										
February										
March										
April										
May										
June										
July										
August										
September										
October										
November										
December										
Annual Total										

** For multifamily buildings, EUIs can be expressed on "per unit" or "per square foot" basis; the former is generally preferred.*

Calculations (use unit conversions in Appendix A if necessary):
F - monthly: (Column 9 x 30 days/month) / (Item 1 x Column 8) or Equation 10
F - annual: (Sum of Column 9 x 365 days/year) / (Item 1 x Sum of Column 8) or Equation 11
G - annualized: (Column 9 x 365 days/year) / (Item 1 x Column 8) or Equation 12

Figure 5. Energy Use Index Worksheet (cont.)

Table 3. Distribution of Annual Electrical Energy Use Indices for Commercial Buildings

Commercial Building Type	Annual Electrical Consumption (kWh/ft²)			Annual Electrical Peak Demand (W/ft²)			Annual Electrical Load Factor (ELF)			Annual Electrical Occupancy Load Factor (EOLF)		
	Low	Mid	High	Low	Mid	High	Low	Mid	High	Low	Mid	High
Education	4.0	7.0	11.4	2.39	4.52	7.97	0.134	0.177	0.242	0.514	0.674	0.955
Food Sales	20.0	42.3	66.4	7.93	12.25	17.78	0.412	0.514	0.587	0.659	0.820	1.132
Food Service	15.6	28.9	50.2	6.00	11.43	18.75	0.259	0.319	0.371	0.477	0.060	0.778
Health Care	6.8	10.8	17.6	3.13	4.47	8.13	0.166	0.274	0.364	0.482	0.673	0.823
Lodging	5.7	12.2	21.5	2.62	4.90	8.50	0.268	0.333	0.436	0.292	0.373	0.526
Mercantile & Service	3.1	6.7	13.4	2.31	4.25	7.90	0.189	0.253	0.337	0.584	0.773	0.980
Office	4.4	9.6	17.6	3.24	5.19	8.00	0.202	0.258	0.332	0.736	1.041	1.361
Parking Garage	2.6	6.2	10.9	1.77	5.50	8.89	0.102	0.256	0.394	0.408	0.510	0.879
Public Assembly	1.7	4.3	10.1	2.38	4.47	7.43	0.094	0.163	0.254	0.435	0.599	0.941
Public Order &Safety	2.9	8.2	11.8	2.15	3.21	8.10	0.205	0.299	0.346	0.266	0.450	0.820
Religious Worship	1.1	2.4	3.7	2.39	4.32	8.00	0.056	0.084	0.123	0.395	0.576	1.271
Warehouse & Storage	1.3	3.1	6.1	1.21	2.57	5.00	0.139	0.215	0.309	0.572	0.811	1.091
Other	1.7	5.5	26.5	2.07	6.33	11.88	0.121	0.369	0.560	0.531	0.659	1.065
Vacant	0.4	1.6	4.4	1.00	1.88	4.88	0.081	0.167	0.263	0.368	0.681	1.043

Notes: Select the appropriate column (Low, Mid, or High) for comparison according to your climate intensity and the relative intensity of a building's loads. Monthly ELFs and EOLFs may be slightly higher than annual values.

Source: EIA, *Commercial Buildings Energy Consumption and Expenditures 1992*.

Table 4. Distribution of Annual Natural Gas Consumption Indices for Typical Commercial Buildings

Commercial Building Type	Annual Natural Gas Consumption (kBtu/ft²) Low	Mid	High
Education	17.5	31.1	62.2
Food Sales	13.8	27.6	84.8
Food Service	83.7	150.8	244.5
Health Care	21.6	40.8	93.5
Lodging	35.7	74.1	140.8
Mercantile and Service	16.4	36.6	70.6
Office	15.0	31.2	61.7
Parking Garage	49.6	100.4	211.8
Public Assembly	12.8	32.9	69.2
Public Order and Safety	44.8	62.0	124.8
Religious Worship	12.1	27.5	46.9
Warehouse and Storage	10.9	26.2	55.5
Other	7.0	33.2	153.0
Vacant	9.2	24.4	54.6

Note: Select the appropriate column (Low, Mid, or High) for comparison according to your climate intensity and the relative intensity of a building's loads.

Source: EIA, *Commercial Buildings Energy Consumption and Expenditures 1992*.

category. The national sample of building EUIs is geographically distributed to help negate the effects of varying climates within the United States, with the possible exception of regions that experience extreme weather patterns. Indices for multifamily buildings that use electricity, natural gas, fuel oil, or a combination of gas and oil may be looked up in Table 5. The values shown in Table 5 represent averages for the entire sample of multifamily dwelling units, and these are then split between rental and owned dwellings. Since the residential sample for large multifamily buildings is somewhat smaller than the sample for commercial buildings, the indices in Table 5 are reported at a lower (but still statistically significant) level of detail (i.e., "low" and "high" consumption categories are not available).

Comparing your building indices to national "average" annual indices allows you to determine whether buildings in your stock are using more or less energy than most similar buildings in the nation. If the index values for your buildings are generally higher than the "high" values, there is likely to be a significant opportunity for energy savings. In addition to this comparison with national values, similar buildings within your stock should be compared to each other to determine which buildings appear to offer the greatest opportunities for savings. If you and your team were able to obtain average building energy use data for your region, comparison of your EUIs to that data set will probably yield the most reliable indication of building energy performance.

Table 5. U.S. Multifamily Annual Energy Use Indices (with 5 or more units)

Electricity	kWh/ft²	kWh/unit	ft²/unit
Total Occupancy	7.11	5761	810
Own	5.71	7494	1313
Rent	7.47	5511	738
Natural Gas/No Oil	**kBtu/ft²**	**MBtu/unit**	**ft²/unit**
Total Occupancy	58	45	789
Own	41	53	1306
Rent	61	45	738
Fuel Oil/No Gas	**kBtu/ft²**	**MBtu/unit**	**ft²/unit**
Total Occupancy	56	37	662
Own	—	—	—
Rent	57	36	628
Dual Fuel/Gas & Oil	**kBtu/ft²**	**MBtu/unit**	**ft²/unit**
Total Occupancy	63	68	1081
Own	45	62	1382
Rent	72	70	972

Source: EIA, Residential Energy Consumption Survey 1990.

For individual buildings with high monthly or annual EUIs (or a low Electric Load Factor), Table 6 shows how the EUIs can be used to identify potential savings opportunities. These generic suggestions may not address all available possibilities for consumption and/or demand problems, but when used in conjunction with the EUIs, monthly data, and a knowledge of the building, they can provide useful insight into building behavior and energy performance. (The selection of specific energy efficiency measures is discussed in greater detail in Chapter 6.) The references listed at the end of this chapter provide further information that will assist you in understanding building energy behavior and identifying conservation opportunities.

Graphing the Indices for Further Analysis

As suggested earlier, graphical representations of building EUIs help energy analysts to quickly gain insight into the way a building uses energy. Your team may elect to graph the indices for those buildings that appear to be the biggest energy users or for any buildings that produce surprising results in the first analysis. If you are using a computerized system, you will probably want to go ahead and employ graphical analysis on all of your targeted building stock. Analysis of energy-savings potential in buildings can often be complicated, and one of the more difficult aspects is

adjusting for changes in weather over time. One technique that allows a reasonable estimation of benefits without explicit corrections for weather uses 12-month "moving" sums of energy consumption. The 12-month moving window of annual EUIs (from Equations 2 and 11) can be used to visualize monthly energy consumption, while minimizing effects due to weather. The moving window is achieved by plotting, for each month, the sum of consumption for that month plus the previous 11 months. To plot a chart for one year, two years of data must be collected.

A simple example of how the annual electricity use index can be used for comparing buildings is presented in Figure 6. Graphs are shown for four office buildings, none of which use electricity for cooling. The graph displays the 12-month (annual) moving total of kWh on a per square foot basis over the period from 1992 through 1995. As noted above, each data point on the line represents the EUI for that month plus the previous 11 months. That is, the point for June 1992 represents the EUI for July 1991 through June 1992. Floor areas are shown on the graph so that total annual electricity use for each building may be estimated if desired.

As shown in the figure, Office Building 1 exhibits very high electricity use (in comparison with the national statistics shown in Table 3). Some decrease is observed from 1992 to 1995, suggesting that some action has already been taken to reduce energy use. The high consumption may be explained by the presence of a large computer facility or some other electricity-intensive activity. Chances are, however, that Building 1 can significantly benefit from an energy-efficient retrofit. The building warrants a quick site visit to determine if the high electricity levels can be justified. Building 2 also exhibits high electricity use and should be considered for further investigation. Although a dip in energy use is evident, the building's energy use is consistently above the national "high" consumption level.

Building 3 shows a steady increase in energy consumption over the last several years. Differences in weather between the years would not explain the increase, nor would floorspace additions to the building (since the consumption is given on a per square foot basis). A change in principal building activity could account for the increase, but the building owner or operator should be contacted to identify the reason. Building 4 is well below the "high" consumption level and does not exhibit any obvious "spikes" in energy use over the last several years. Accordingly, other buildings in your community may benefit more from a retrofit. Remember that, if possible, you should compare your building EUIs to indices based on local and regional building stock data.

Graphical analysis of additional indices can offer further insight on building performance. Annualized consumption indices (from Equation 3) may be plotted and examined to identify seasonal or unusual fluctuations in consumption. Monthly and seasonal anomalies in the data can reveal

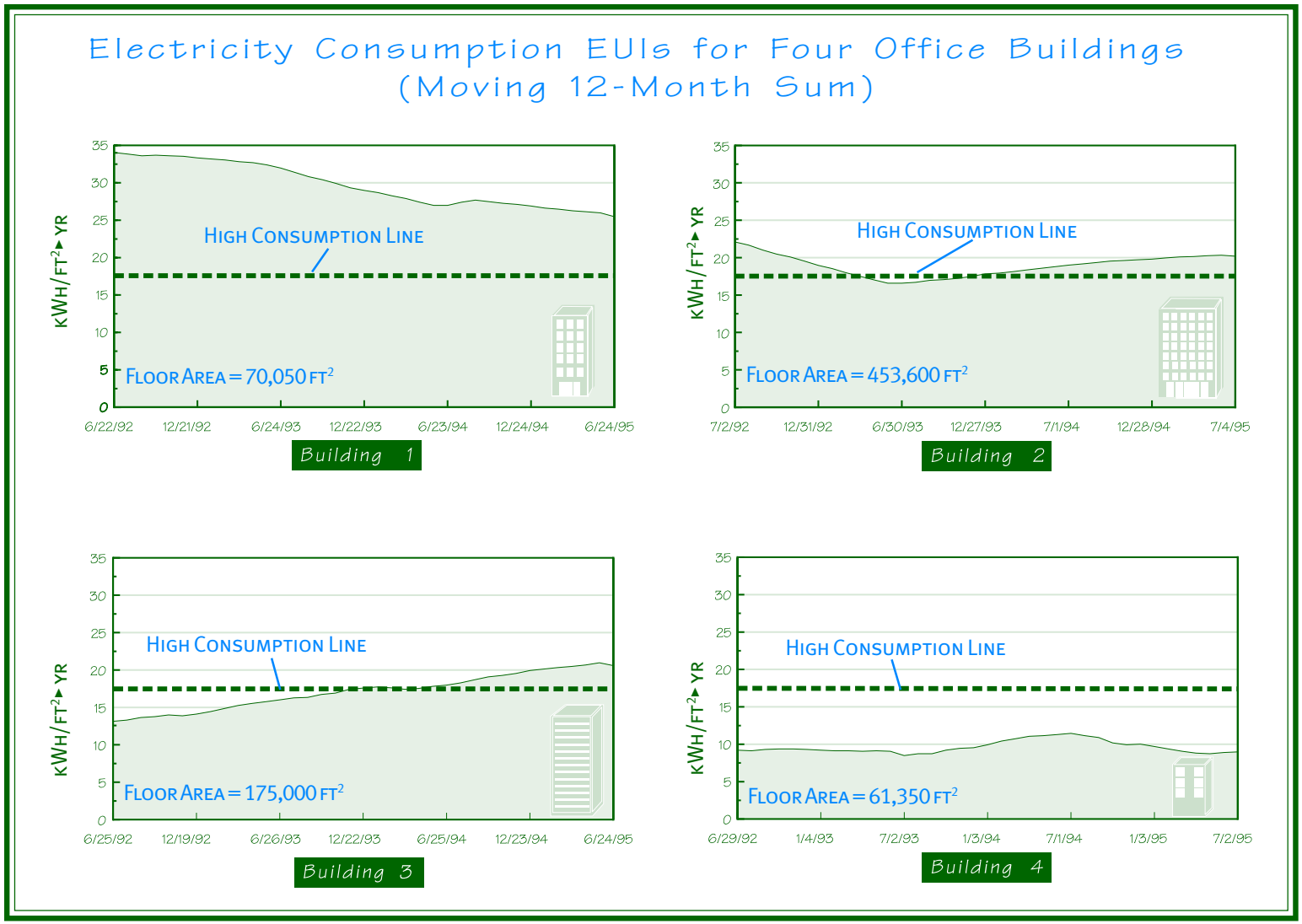


Figure 6. A Graphical Representation of Month-by-Month Moving Annual EUIs for Electricity

Table 6. Possible Sources for Savings Opportunities

Identification Factor	Possible Source	Investigate
High Electrical Consumption Index	Inefficient HVAC	Air-conditioning equipment, heating equipment, air/water distribution system
	After-Hours Equipment Operations	HVAC controls, lighting, office equipment, refrigerating equipment, inefficient exterior lighting
	Building Envelope	Excessive infiltration from open doors or loading docks, high solar loads from large amounts of glazing
High Peak Electrical Demand Index	Electric Resistance Heating	Main heating system, supplemental heating, cooking equipment
	Inefficient Lighting System	Amount of incandescent and/or fluorescent-magnetic ballast lighting in use
	Electrical Equipment	Large computers or large number of computers in use
Low Electrical Load Factor	Electric Resistance Heating	Main heating system, supplemental heating (heat pump supplement or portable heaters)
	Oversized HVAC Equipment	Proper sizing of equipment for building load, excessive short cycling of equipment
	Billing Errors	Previous electric utility bills (contact electric utility company)
High Electrical Occupancy Load Factor	After-Hours Lighting	Interior lighting unnecessarily used after-hours, inefficient exterior lighting
	After-Hours HVAC Use	HVAC controls
	Miscellaneous Equipment	Unused computers, refrigerators or freezers
High Natural Gas Consumption Index	After-Hours Heating Use	Heating controls
	Building Envelope	Excessive infiltration from open doors or loading docks
	Inefficient Use of Gas	Heating system efficiency, combustion efficiency, distribution system

Source: Oak Ridge National Laboratory.

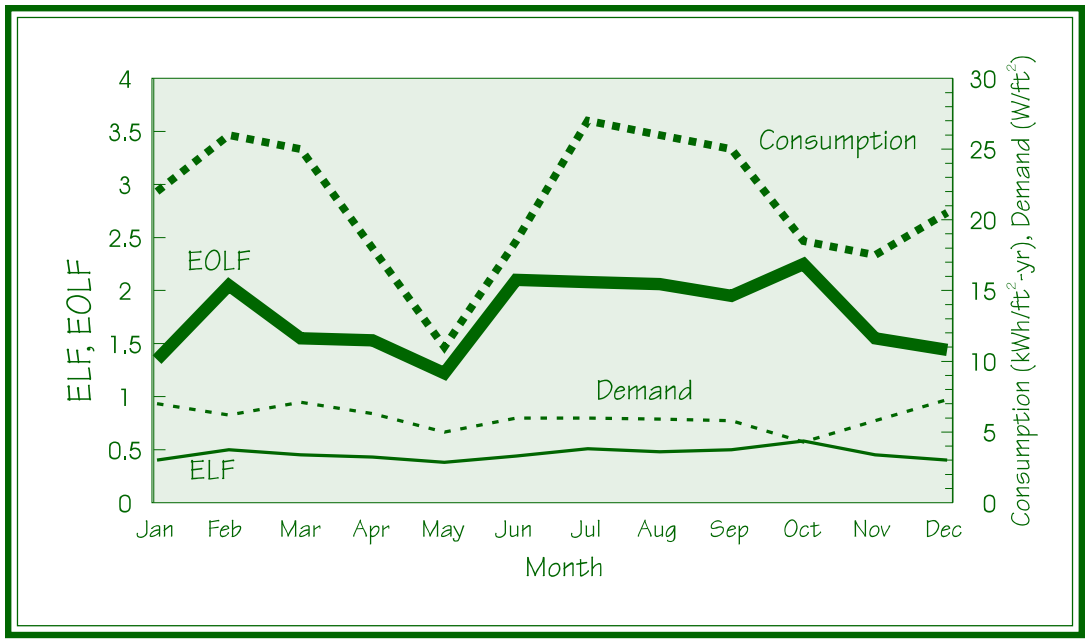


Figure 7. Graphical Representation of Annualized Monthly Electricity and Demand Indices

opportunities to save energy or the graphs can later be used simply to verify savings as a result of planned efficiency measures. As an example, Figure 7 shows the monthly EUIs for a small office building (3,700 ft²) located in the Southeast. Specifically, the figure shows "annualized" consumption indices (on a monthly basis), load factors, and demand indices for 12 months. Here, the annualized consumption for the building is high at 21.8 kWh/ft², compared to the nation's high of 17.6 kWh/ft² (Table 3). Since the EOLF (Equation 8) is larger than 1.5 for a majority of the year, excessive after-hours consumption may be occurring and contributing to the higher consumption index. During the winter months, demand levels (at 8.0 W/ft²) are also high when compared to the national distribution for offices. The high demand for electricity (Equation 4) during the heating season indicates that an inefficient electric-resistance heating system may exist. Additionally, demand indices are high all year, signaling that the building has an inefficient, possibly oversized, lighting system.

References

Abraham, M. M. and J. M. MacDonald. 1995. *Energy Conservation Opportunities in Small Commercial Buildings.* Oak Ridge, TN: Oak Ridge National Laboratory, ORNL/CON-414.

Akbari. 1993. *Measured Commercial Load Shapes and Energy-Use Intensities and Validation of the LBL End-Use Disaggregation Algorithm.* Berkeley, CA: Lawrence Berkeley Laboratory, LBL-32193.

ASHRAE. 1995. *1995 HVAC Applications Handbook.* Atlanta: American Society of Heating, Refrigerating and Air-Condition ing Engineers. Chapters 2-7 and 32.

ASHRAE. 1993. *1993 Fundamentals Handbook.* Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers. Chapter 26.

CBECS. 1995. *Commercial Buildings Energy Consumption and Expenditures 1992.* U.S. Department of Energy, Energy Information Administration, DOE/EIA-0318(92).

Komor. 1989. Investigating an Analytical Basis for Improving Commercial Building Energy Audits: Early Results from a New Jersey Mall. *Proceedings of the Thermal Performance of the Exterior Envelopes of Buildings IV.* Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, pp. 587-612.

McLain. 1994. *Analysis of Savings Due to Multiple Retrofits in a Large Office Building.* Oak Ridge, TN: Oak Ridge National Laboratory, ORNL/CON-363.

McLain. 1988. *An Analytical Investigation of Energy End-Use in Commercial Office Buildings.* Oak Ridge, TN: Oak Ridge National Laboratory, ORNL/CON-250.

RECS. 1993. Residential Energy Consumption Survey 1990 (public use data files). U.S. Department of Energy, Energy Information Administration, DOE/EIA-0321(90) and DOE/EIA-0314(90).

How to Finance Your Retrofit Program

Cost and financing issues are pivotal factors in determining which energy efficiency measures will be included in your final energy management plan. Even at this early stage in your program, therefore, you and your team should take a look at the cost and financing issues, begin developing some rough cost estimates, and consider your financing options. After completing more detailed analyses later in the process, you will be able to refine these initial cost estimates and select the best way to finance your program.

Before you examine your financing options, of course, you will need to have a reasonably good approximation of the measures that may be implemented. For this purpose, you will want to perform cost/benefit analyses on each candidate measure to identify those with the best investment potential. This chapter presents a brief introduction to cost/benefit methods and then suggests a variety of options for financing your program.

Selecting a Cost/Benefit Analysis Method

In analyzing alternative building energy improvements, cost/benefit analysis is used to determine if and when an improvement will pay for itself through energy savings, and to set priorities among alternative improvement projects (Thumann 1991, NBS 1980, Newnan 1977). Cost/benefit analyses may be conducted using a simple payback analysis or a more sophisticated analysis of total life cycle costs and savings. Since most electric utility rate schedules are based on both consumption and peak demand, your analyst should be skilled at assessing the impacts of changes in both electricity use and demand on total cost savings, regardless of which type of analysis is used.

Before beginning any cost/benefit analyses, you must first determine acceptable design alternatives that can meet the heating, cooling, lighting, and control requirements of

the building being evaluated. The criteria for determining whether a design alternative is "acceptable" should include reliability, safety, conformance with building codes, occupant comfort, noise levels, and even space limitations. Since there will usually be a number of acceptable alternatives for any project, benefit-cost analyses allow you to select those that have the best savings potential.

Simple Payback Analysis

A highly simplified form of cost/benefit analysis is called simple payback. In this method, the total first cost of the improvement is divided by the first-year energy cost savings produced by the improvement. This method yields the number of years required for the improvement to pay for itself.

Simple Payback

As an example of simple payback, consider the lighting retrofit of a 10,000-square-foot commercial office building. Relamping with T-8 lamps and electronic, high-efficiency ballasts may cost around $13,300 ($50 each for 266 fixtures) and produce annual savings of around $4,800 per year (80,000 kWh at $0.06/kWh). The simple payback time for this improvement would be

$$\frac{\$13{,}300}{\$4{,}800/\text{year}} = 2.8 \text{ years}$$

That is, the improvement would pay for itself in 2.8 years, a 36% simple return on the investment (1/2.8 = 0.36).

In simple payback analysis, you are assuming that the service life of the energy efficiency measure will equal or exceed the simple payback time. Simple payback analysis provides a relatively easy way to examine the overall costs and savings potentials for a variety of project alternatives. However, it does not consider a number of factors that are difficult to predict, yet can have a significant impact on cost savings. These factors may be considered by using a more sophisticated life cycle cost (LCC) analysis.

Life Cycle Cost Analysis

Life cycle costing is an analysis of the total cost of a system, device, building, or other capital equipment or facility over its anticipated useful life. LCC analyses allow a comprehensive assessment of all anticipated costs associated with a design alternative. Factors commonly considered in LCC analyses are initial capital cost, operating costs, maintenance costs, financing costs, the expected useful life of equipment, and its future salvage values. The result of the LCC analysis is generally expressed as the value of initial and future costs in today's dollars (Lippiatt 1995), as reflected by an appropriate discount rate.

The first step in performing an LCC analysis is to establish the general study parameters for the project, including the base date (the date to which all future costs are discounted), the service date (the date when the new system will be put

into service), the study period (the life of the project or the number of years over which the investor has a financial interest in the project), and the discount rate. When two or more design alternatives are to be compared (or even when a single alternative is compared against an existing design), these variables must be the same for each to assure that the comparison is valid. It is meaningless to compare the LCC of two or more alternatives if they are computed using different study periods or different discount rates.

Decision makers in both the public and private sectors have long used life cycle costing to obtain an objective assessment of the total cost of owning, operating, and maintaining a building or building system improvement over its useful life. Nevertheless, an LCC analysis does require the use of sound judgment as to acceptable alternatives, useful life, equipment efficiencies, and discount rates.

Selecting the "Best" Alternatives

Generally, all project alternatives should be initially screened using simple payback analyses. A more detailed and costly LCC analysis should be reserved for large projects or those improvements that entail a large investment, since a detailed cost analysis would then be a small part of the overall cost. Both simple payback and LCC analyses will allow you to set priorities based on measures that represent the greatest return on investment. In addition, these analyses can provide a preliminary indication of appropriate financing options, as follows:

- Energy efficiency measures that have a short payback period, such as 1 to 2 years, are the most attractive economically, and should be considered for implementation using operating reserves or other readily available internal funds.

- Energy efficiency measures that have payback periods from 3 to 5 years may be considered for funding from available internal capital investment monies, or may be attractive candidates for third-party financing through energy service companies or equipment leasing arrangements.

- Frequently, short payback measures can be combined with longer payback measures (10 years or more) in order to increase the number of measures that can be cost-effectively included in a project. Projects that combine short- and long-term paybacks are recommended by Rebuild America to avoid "cream-skimming" (implementing only those measures that are highly cost effective and have quick paybacks) at the expense of other worthwhile measures. A selected set of measures with a combination of payback periods can be financed either from available internal funds or through third party alternatives.

If simple payback time is long, 10 or more years, economic factors can be very significant and LCC analysis is recommended. In contrast, if simple payback occurs within three to five years, more detailed LCC analysis may not be necessary, particularly if price and inflation changes are assumed to be moderate. Under this assumption, a simple payback analysis will often be within 15 to 20% of the payback time estimated from a detailed LCC analysis. In general, detailed life cycle cost analyses may not be justified if the payback of the improvement is under five years.

The key is knowing where to look and how to choose the best financing arrangement.

Weighing Non-Cost Impacts

Some factors related to building heating, air conditioning, and lighting system design are not considered in either simple payback or LCC analyses. Examples include the thermal comfort of occupants in a building and the adequacy of task lighting, both of which affect productivity. A small loss in productivity due to reduced comfort or poor lighting can quickly offset any energy cost savings.

Conventional cost/benefit analyses also normally do not consider the ancillary societal benefits that can result from reduced energy use (e.g., reduced carbon emissions, improved indoor air quality). In some cases, these ancillary benefits can be assigned an agreed upon monetary value, but the values to be used are strongly dependent on local factors. In general, if societal benefits have been assigned appropriate monetary values by a local utility, they can be easily considered in your savings calculations. However, your team should discuss this issue with your local utility or consultants working on such values in your area.

Finally, in any cost analysis, it can be very important to include avoided cost as part of the benefit of the retrofit. When upgrading or replacing building equipment, the avoided cost of maintaining existing equipment should be considered a cost savings provided by the improvement. The purpose of performing cost/benefit analyses at this point is primarily to narrow the selection of potential measures. Further economic evaluation of individual measures will be conducted during the detailed planning for implementation, as discussed in Chapter 7.

Financing Mechanisms

Financing can be one of the most critical elements for efficiency renovations. It determines how much can actually be accomplished. The key is knowing where to look and how to select the most appropriate financing mechanism.

Capital for energy efficiency improvements is available from a variety of public and private sources, and can be accessed through a wide and flexible range of financing instruments. While variations may occur, there are five general financing mechanisms available today for investing in energy efficiency:

- **Internal Funds.** Energy efficiency improvements are financed by direct allocations from an organization's own internal capital or operating budget.

- **Debt Financing.** Energy efficiency improvements are financed with capital borrowed directly by an organization from private lenders.

- **Lease or Lease-Purchase Agreements.** Energy-efficient equipment is acquired through an operating or financing lease with no up-front costs, and payments are made over five to ten years.

- **Energy Performance Contracts.** Energy efficiency measures are financed, installed, and maintained by a third party, which guarantees savings and payments based on those savings.

- **Utility Incentives.** Rebates, grants, or other financial assistance is offered by an energy utility for the design and purchase of certain energy-efficient systems and equipment.

These financing mechanisms are not mutually exclusive (i.e., an organization may use several of them in various combinations). The most appropriate set of options will depend on the type of organization (public or private), size and complexity of a project, internal capital constraints, in-house expertise, and other factors. Each of these mechanisms is discussed briefly below, followed by some additional funding sources and considerations.

Internal Funds

The most direct way for the owner of a building or facility to pay for energy efficiency improvements is to allocate funds from the internal capital or operating budget. Financing internally has two clear advantages over the other options discussed below—it retains internally all savings from increased energy efficiency, and it is usually the simplest option administratively. The resulting savings may be used to decrease overall operating expenses in future years or retained (all or some portion of them) within a revolving fund and used to support additional efficiency investments. Many public and private organizations regularly finance some or all of their energy efficiency improvements from internal funds.

In some instances, competition from alternative capital investment needs and the requirement for relatively high rates of return may limit the use of internal funds for major, stand-alone investments in energy efficiency. In most organizations, for example, the highest priorities for internal funds are business or service expansion, critical health and safety needs, or productivity enhancements. In both the public and private sectors, capital that remains available after these priorities have been met will usually be invested in those areas that offer the highest rates of return. The criteria for such investments commonly

include an annual return of 20 to 30 percent or a simple payback of three years or less.

Since comprehensive energy efficiency improvements commonly have simple paybacks of five to six years, or about a 12-percent annual rate of return, internal funds cannot realistically be expected to serve as the sole source of financing for such improvements. Alternatively, however, internal funding can be used well and profitably to achieve more competitive rates of return when combined with one or more of the other options discussed below.

Debt Financing

Direct borrowing of capital from private lenders can be an attractive alternative to the allocation of internal funding for energy efficiency investments. For both government and business organizations, this approach avoids tapping internal funding, and financing costs can be repaid by the savings that accrue from increased energy efficiency. Additionally, municipal governments can often issue bonds or other long-term debt instruments at substantially lower interest rates than can private corporate entities. As in the case of internal funding, all savings from efficiency improvements (less only the cost of financing) are retained internally.

Debt financing is administratively more complex than internal funding, and financing costs will vary according to the credit rating of the borrower. This approach may also be restricted by formal debt ceilings imposed by corporate or municipal policy, accounting standards, and/or Federal or state legislation. As a key example of the latter, the Tax Reform Act of 1986 placed a cap on the total amount of revenue bonds that a state and its local public agencies may issue. This cap has resulted in substantial competition for the available bonds and can reduce the availability of tax-favored financing.

In general, debt financing should be considered for larger retrofit projects that involve multiple buildings or facilities and that pose relatively little risk in collectively achieving their energy savings targets. When considering debt financing, organizations should weigh the cost and complexity of this type of financing against the size and risk of the proposed projects.

Lease and Lease-Purchase Agreements

Leasing and lease-purchase agreements provide a means to reduce or avoid the high, up-front capital costs of new, energy-efficient equipment. These agreements may be offered by commercial leasing corporations, management and financing companies, banks, investment brokers, or equipment manufacturers. As with direct borrowing, the lease should be designed so that the energy savings are sufficient to pay for the financing charges. While the time period of a lease can vary significantly, leases in which the

Types of Leasing Agreements

Operating Leases are usually for a short term, occasionally for periods of less than one year. At the end of the lease period, the lessee may either renegotiate the lease, buy the equipment for its fair market value, or acquire other equipment. The lessor is considered the owner of the leased equipment and can claim tax benefits for its depreciation.

Financing Leases are agreements in which the lessee essentially pays for the equipment in monthly installments. Although payments are generally higher than for an operating lease, the lessee may purchase the equipment at the end of the lease for a nominal amount (commonly $1.00). The lessee is considered the owner of the equipment and may claim certain tax benefits for its depreciation.

Municipal Leases are available only to tax-exempt entities such as school districts or municipalities. Under this type of lease, the lessor does not have to pay taxes on the interest portion of the lessee's payments, and can therefore offer an interest rate that is lower than the rate for usual financing leases.

Because of restrictions against multiyear liabilities, the municipality specifies in the contract that the lease will be renewed year by year. This places a higher risk on the lessor, who must be prepared for the possibility that funding for the lease may not be appropriated. The lessor may therefore charge an interest rate that is as much as 2 percent above the tax-exempt bond rate, but still lower than rates for regular financing leases. Municipal leases nonetheless are generally faster and more flexible financing tools than tax-exempt bonds.

Guaranteed Savings Leases are the same as financing or operating leases — but with the addition of a guaranteed savings clause. Under this type of lease, the lessee is guaranteed that the annual payments for leasing the energy efficiency improvements will not exceed the energy savings generated by them. The owner pays the contractor a fixed payment per month. If actual energy savings are less than the fixed payment, however, the owner pays only the small amount saved and receives a credit for the difference.

lessee assumes ownership of the equipment generally range from five to ten years. There are several different types of leasing agreements, as shown in the box. Specific lease agreements will vary according to lessor policies, the complexity of the project, whether or not engineering and design services are included, and other factors.

Energy Performance Contracts

Energy performance contracts are generally financing or operating leases provided by an Energy Service Company (ESCo) or equipment manufacturer. The distinguishing feature of these contracts is that they provide a guarantee on energy savings from the installed retrofit measures, and they usually also offer a range of associated design, installation, and maintenance services. The contract period can range from five to ten years, and the customer is required to have a certain minimum level of capital investment (generally $200,000 or more) before a contract will be considered.

Under an energy performance contract, the ESCo provides a service package that typically includes the design and engineering, financing, installation, and maintenance of retrofit measures to improve energy efficiency. The scope of these improvements can range from measures that affect a single part of a building's energy-using infrastructure (such as lighting) to a complete package of measures for multiple buildings and facilities. Generally, the service provider will guarantee savings as a result of improvements in both

energy and maintenance efficiencies. Flat-fee payments tend to be structured to maintain a positive cash flow to the customer with whom the agreement is made. With the increasing deregulation of conventional energy utilities, several larger utilities have formed unregulated subsidiaries that offer a full range of energy efficiency services under performance agreements.

Utility Assistance

Equipment Rebates. Some utilities offer rebates on the initial purchase price of selected energy-efficient equipment. The amount of the rebate varies substantially depending on the type of equipment. For example, a rebate of $0.50 to $1.00 may be offered for the replacement of an incandescent bulb with a more efficient fluorescent lamp, while the installation of an adjustable-speed drive may qualify for a rebate of $10,000 or more.

Design Assistance. A smaller number of utilities provide direct grants or financial assistance to architects and engineers for incorporating energy efficiency improvements in their designs. This subsidy can be based on the square footage of a building, and/or the type of energy efficiency measures being considered. Generally, a partial payment is made when the design process is begun, with the balance paid once the design has been completed and installation has commenced.

Low-Interest Loans. Loans with below-market rates are provided by other utilities for the purchase of energy-efficient equipment and systems. Typically, these low-interest loans will have an upper limit in the $10,000 to $20,000 range, with monthly payments scheduled over a two- to five-year period.

An energy performance contract must define the methodology for establishing the baseline costs and cost savings and for the distribution of those savings among the parties. The contract must also specify how those savings will be determined, and must address contingencies such as utility rate changes and variations in the use and occupancy of a building. While several excellent guidance documents exist for selecting and negotiating energy performance contracts, large or complicated contracts should be negotiated with the assistance of experienced legal counsel.

Utility Incentives

Some utilities still offer financial incentives for the installation of energy-efficient systems and equipment, although the number and extent of such programs appears to be decreasing as utility deregulation proceeds. These incentives are available for a variety of energy-efficient products including lighting, HVAC systems, energy management controls, and others. The most common incentives are equipment rebates, design assistance, and low-interest loans.

In general, the primary purpose of utility incentives is to lower peak demand; overall energy efficiency is an important, but secondary consideration. Incentives are much more commonly offered by electric utilities than by natural gas utilities. The extent to which these incentives will be continued or expanded by the utility industry is uncertain.

Additional Financing Sources and Considerations

State and Federal Assistance. Matching grants, loans, or other forms of financial assistance (in addition to those listed above) may be available from the Federal government or state governments. If your community is considering energy efficiency improvements for public or assisted multifamily housing, your program could be eligible to receive assistance through various programs of the U.S. Department of Housing and Urban Development. A variety of state-administered programs for building efficiency improvements may also be available, some of which are funded through Federal block grants and programs. Federal assistance available through states include Federal block grants and State Energy Conservation Program (SECP) funds. Two examples of individual state programs include the Texas LoanSTAR program, which provides low-interest loans for state agencies and schools, and the Iowa Energy Bank program, which provides loans, leases, and other methods of alternative financing for state agencies, schools, community colleges, and non-profit organizations. Check with your state energy office for programs available in your state.

Bulk Purchasing. Large organizations generally have purchasing or materials procurement departments that often buy standard materials in bulk or receive purchasing discounts because of the volume of their purchases. Such organizations can help reduce the costs of energy efficiency renovations if their bulk purchasing capabilities can be used to obtain discounts on the price of materials (e.g., lamps and ballasts). While some locales may have restrictions that limit the use of this option, some type of bulk purchasing can usually be negotiated to satisfy all parties involved.

Project Transaction Costs. Certain fixed costs are associated with analyzing and installing energy measures in each building included in a retrofit program. Each additional building, for example, could represent additional negotiations and transactions with building owners, building analysts, energy auditors, equipment installers, commissioning agents, and other contractors. Similarly, each additional building will add to the effort involved in initial data analysis as well as in tracking energy performance after the retrofit. For these reasons, it is often possible to achieve target energy savings at lower cost by focusing only on those buildings that are the largest energy users. One disadvantage with larger buildings is that the energy systems in the building can be more difficult to understand, but overall, focusing on the largest energy users is often the most efficient use of your financial resources.

Direct Value-Added Benefits. The primary value of retrofits to buildings and facilities lies in the reduction of operating costs through improved energy efficiency and maintenance savings. Nevertheless, the retrofit may also directly help address a variety of related concerns, and these benefits (and avoided costs) should be considered in assessing

the true value of an investment. A few examples of these benefits include compliance with Federal requirements for phasing out chlorofluorocarbon (CFC) refrigerants in air-conditioning equipment; the improvement of indoor air quality in office buildings and schools; easier disposal of toxic or hazardous materials found in energy-using equipment; and assistance in meeting increasingly stringent state or Federal mandates for water conservation. Effective energy management controls for buildings can also provide a strong electronic infrastructure for improving security systems and telecommunications.

Economic Development Benefits. In addition to direct savings on operating costs and the added-value benefits mentioned above, investments in energy efficiency can also support a community's economic development and employment opportunities. Labor will typically constitute about 60% of a total energy investment, and about 50% of equipment can be expected to be purchased from local equipment suppliers; as a result, about 85% of the investment is retained within the local economy. Additionally, funds retained in urban areas will generally be respent in the local economy. The Department of Commerce estimates that each dollar retained in an urban area will be respent three times. This multiplier effect results in a threefold increase in the economic benefits of funds invested in energy efficiency, without even considering the savings from lower overall fuel costs.

References

Cost/Benefit Analysis

Greely, K.M., J.P. Harris, and A.M. Hatcher. 1989. *Measured Savings and Cost-Effectiveness of Conservation Retrofits in Commercial Buildings, Vol. I: Analysis and Results.* Lawrence Berkeley Laboratory, LBL-27568.

Lippiatt, B.C. 1995. *Energy Prices and Discount Factors for Life-Cycle Cost Analysis 1994.* Washington, DC: U.S. Department of Commerce, NISTIR 85-3273-7.

NBS. 1980. *Life-Cycle Cost Manual for the Federal Energy Management Program.* National Bureau of Standards, NBS-135.

Newnan, D.G. 1977. *Engineering Economic Analysis.* San Jose, CA: Engineering Press.

Saman, N.F., et al. 1995. Empirical Correlations between Annual Cost Savings and Implementation Costs for Various Categories of Energy Conservation Retrofit Projects in Commercial Buildings. *Proceedings of the 1995 ASME/JSME/JSES International Solar Energy Conference.* Maui, HI.

Thumann, A. 1991. *Plant Engineers and Managers Guide to Energy Conservation.* Atlanta, GA: Association of Energy Engineers.

Wendes, H.C. 1994. *HVAC Retrofits: Energy Savings Made Easy.* Atlanta, GA: Association of Energy Engineers

Financing

Alliance to Save Energy. 1982. *Third-Party Financing: Increasing Investment in Energy Efficient Industrial Projects.* Washington, DC: Alliance to Save Energy.

Brealey, R. and S. Myers. 1981. *Principles of Corporate Finance.* New York: McGraw Hill Book Co.

Hansen, S.J. 1993. *Performance Contracting for Energy and Environmental Systems.* Lilburn, GA: Fairmont Press.

Goldberger, D.J. and P. Jessup. 1994. *Profiting from Energy Efficiency! A Financing Handbook for Municipalities.* Toronto, Ontario, Canada: International Council for Local Environmental Initiatives.

U.S. DOE and HUD. 1992. *Energy Performance Contracting for Public and Indian Housing: A Guide for Participants.* Prepared by the Energy Division of the Oak Ridge National Laboratory for the Department of Energy and U.S. Department of Housing and Urban Development. (Available from the U.S. Department of Housing and Urban Development, Washington, DC.)

Washington International Energy Group. 1995. *The 1995 Electric Industry Outlook.* Washington, DC: Washington International Energy Group.

Winter, Mary Ellen. 1993. *Financing Local Energy Efficiency Projects.* Unpublished article. National Renewable Energy Laboratory. (Available through the U.S. Department of Energy, EREC, Washington, DC.)

How to Develop an Action Plan

Developing an Action Plan is a critical step in the renovation process. The Action Plan should serve as a detailed road map that will guide your partnership through the implementation, management, and monitoring of energy efficiency improvements in selected buildings and facilities. When completed, it should be formally adopted by your partnership and, if appropriate, by your local policy-making bodies (subject to their regular budget-making, oversight, and performance evaluation procedures). This chapter provides information on the key components that should be included in your Action Plan.

While the commitment to develop an Action Plan is sufficient for initial recognition as a Rebuild America partner by DOE, a completed plan is essential before real energy-saving results can be achieved within the local community. Submission of a completed Action Plan to Rebuild America is also required before a partnership will be eligible for either financial support or customized technical assistance from DOE. If your partnership applies for financial support through the Rebuild America solicitation, however, the Action Plan is incorporated in your application.

While Action Plans may differ significantly in their level of detail, sophistication, and coverage, all plans should address five major elements: (1) priorities, goals, and organization; (2) candidate buildings for renovation; (3) actions, responsibilities, and resources for carrying out the plan; (4) methods for monitoring and evaluating results; and (5) plans for promoting and expanding the program. This five-part framework is outlined below and includes brief descriptions of the elements that should be included.

Priorities, Goals, and Organization

An effective and long-lasting program to produce energy savings must be directly related to broader priorities within your community, such as improved economic development, expanded commercial activity, or more affordable housing. It requires clear goals, top-level support, and a sound organizational structure. This section of the Action Plan should present a concise statement of your community's priorities, the program's energy efficiency goals, and how the organizations within the partnership will act together to meet those goals.

Priorities

State the priorities to be observed in making policy and operational decisions for your partnership. For example, if your community is particularly concerned about economic growth and job creation, you may wish to give priority to achieving energy cost reductions in those commercial buildings that serve the greatest portion of the region's employment base. Alternatively, if housing costs are high, your priorities may focus more strongly on reducing or stabilizing costs through an emphasis on multifamily residential properties. Other concerns that may shape local priorities include environmental issues, urban revitalization, or cost constraints on small businesses. Additional issues may be raised by members of your partnership.

Goals

Once broad priorities have been defined, you can develop an initial estimate of the energy savings potential that best matches those priorities. The initial analysis of your building stock, as discussed in Chapter 3 of this handbook, should provide the basis for realistic estimates of energy and cost-saving goals. DOE suggests that you set a minimum energy savings goal of 25% for the targeted building stock. In addition to the rate of energy savings or efficiency improvements, retrofit goals should be stated in terms of the total floorspace of commercial buildings and the number of dwelling units in multifamily buildings that you intend to address. Finally, you should state a time period within which these goals can be achieved, as well as an estimate of both the capital investment and return-on-investment required to achieve these goals.

Goals should be challenging and clearly stated. They should also be realistically achievable within a reasonable timeframe and cost structure. Later stages of the planning process will enable you to assess the reasonableness of these goals and select specific strategies to achieve them.

Sample Goal

Savings Rate

- 25% average energy efficiency improvement in commercial buildings;
- 30% average energy efficiency improvement in multifamily buildings.

Number and Timeframe

- 500,000 square feet of commercial space addressed in 3 years;
- 5,000 multifamily residential units addressed in 5 years.

Investment

- $_____ capital investment for commercial buildings; average payback = 4 years; and

Return

- $_____ capital investment for multifamily buildings; average payback = 5 years.

Organization and Leadership

This part of the Action Plan should describe the organizations and their roles and responsibilities within your partnership. The management structure should show strong support by top-level management within those organizations. It should also define how local expertise and experience in building energy analysis and energy retrofits will be obtained to assure the effective design, financing, installation, and operation of energy efficiency improvements.

Candidate Buildings for Renovation

The initial screening of your building stock enabled your team to identify those buildings that represent the best candidates for energy-saving renovations. This section of the Plan should identify those candidate buildings along with the characteristics data and energy consumption data that led to their selection. You may also wish to rank other subgroups of buildings in your stock according to their relative potential for future energy savings.

The ranking of candidate buildings should match your program's overall priorities and goals, and may also be used to indicate the direction your partnership intends to take. Examples follow.

- Start-up Objectives. Identify and complete engineering assessments for the buildings with the highest energy use within the community, and develop specific cost and payback estimates. Develop a rational investment and renovation plan based on these assessments.

- Mid-term Objectives. Extend engineering assessments to buildings in the next-highest energy use category as appropriate, based on economic factors, planned renovation schedules, and other relevant considerations.

- Longer-term Objectives. Establish a continuing comprehensive facilities management program within each major organization in the community that owns or operates commercial or multifamily residential buildings to improve the comfort and productivity of building occupants at the least possible energy cost.

This section of your plan should describe the proposed energy efficiency measures (in greater detail than in the initial goal statement), a strategy for carrying them out, and a timeframe for achieving them.

Actions, Responsibilities, and Resources

Meeting the goals and objectives established by your partnership will require staff resources, technical expertise, and financial support. This section of the Action Plan should define the specific actions, responsibilities, and resources needed for meeting those requirements.

Actions should be defined to satisfy both start-up and longer-term objectives as well as local priorities. Technical expertise may be acquired in-house or from experienced contractors, vendors, consultants, or others. Local knowledge of building codes and energy issues can be immensely valuable to efforts of this type. Financing options should consider your own monies, support from private performance contractors, other local industry organizations, any available utility rebates or incentives, and prospects for coordination with other planned building rehabilitation projects. Actions should be outlined for each member of your partnership and for each candidate building. A simplified example for one renovation project follows:

- Planning and Design. Our in-house engineering staff will conduct energy use assessments, define renovation measures, and perform payback analyses for Building "X" during the first quarter of 1996.
- Implementation. Renovations for energy efficiency that have an acceptable internal rate of return will be implemented in conjunction with the planned modernization of Building "X" during the third quarter of 1996.
- Financial Resources. Renovations for energy efficiency will be financed through programmed internal capital investment funds, supplemented by available utility demand reduction incentives, subject to a maximum cost of $_____.

Methods for Monitoring and Evaluating Results

An investment in energy efficiency is a good management decision that can lower any organization's continuing operating costs. However, like any other investment, it makes a demand on the resources of an organization, and that demand must be justified with documented benefits. This section of the Action Plan should define how energy use and cost savings will be measured. It should also outline procedures for reporting those results on a regular basis to DOE and to top-level partnership management. Examples follow.

- Use and Cost Monitoring. Each partnership will maintain a log of historical and current data on monthly

energy use and cost for each building or facility renovated under this program.

- Reporting and Evaluation. Results from the program should be presented annually to the partnership's Executive Committee. This presentation will emphasize annual and cumulative energy use and cost savings. Reports to DOE will be made every six months, as discussed in Chapter 8 of this handbook.

Plans for Promoting and Expanding the Program

Each partnership should define how their local program plans to expand beyond its initial membership to seek continuing participation by the entire community. A key part of this element of the Action Plan is the marketing approach to be followed by the partnership to ensure that the program will grow and endure. Examples of activities that can be defined include the following:

- General Public Awareness. Promotional notices in local newspapers, journals, and electronic media that describe the partnership, its members, and objectives and that solicit other organizations to join and participate actively in the partnership.
- Training and Incentives. Development and delivery of a series of workshops and seminars supported by local utilities, contractors, and builders to provide building owners and managers with basic training on the techniques, financial incentives, and cost-saving benefits of energy efficiency renovations.
- Recognition and Awards. Visible recognition and awards made to organizations and individuals who have carried out successful building renovations, or who have accepted strong leadership responsibilities for the partnership's activities.

6 How to Evaluate Individual Buildings

An on-site energy performance study, known as an energy audit, should be used to identify specific energy- and cost-saving measures that could be implemented in individual buildings. These on-site evaluations can also confirm any cost estimates that may have been developed earlier. This chapter discusses the value of an energy audit and provides guidelines for selecting energy audit and review teams. It also offers pointers on identifying potential energy efficiency measures, discusses the integration of various measures, and offers suggestions for prioritizing the implementation of measures in your plan.

Understanding the Energy Audit

While the initial analysis of your building stock was wide in scope and low in level of detail, your energy audit of individual buildings should be narrowly focused and highly detailed. The energy audits will lead to the identification of specific energy- and cost-saving measures, which may include operations and maintenance activities.

An energy audit should typically produce a report that contains the following elements:

- A comprehensive analysis of energy costs
- Specific recommendations on energy- and cost-saving renovations
- Recommendations to reduce electrical (or other fuel) demand costs
- Estimated costs of energy efficiency measures
- Projected annual energy and cost savings
- Available financial or other support from the utility (or others) for specific measures

- Recommendations on further analysis needed

Although documents describing energy audits are noted at the end of this chapter, your state energy office and local utilities are likely to be valuable sources of information on the procedures used for energy audits in your area. You may also find it helpful to learn about approaches used locally for the Institutional Conservation Program (ICP or Schools and Hospitals Program), conducted under the auspices of the National Energy Conservation Policy Act (Public Law 95-619).

Consider carefully the new mix of skills needed for this phase of your program.

Keep in mind that your efforts should proceed as quickly as possible from the identification of specific measures to actual installation of the retrofits. You will find that the information in the energy audit study goes out of date quickly.

Assembling Your Energy Audit and Review Teams

Personnel skilled at conducting energy audits of buildings are an important resource for determining the specific renovations to be planned for individual buildings. When choosing the energy audit analyst or team, previous experience should be considered. The following are some important factors for consideration:

- Knowledge of costs for energy renovations. Although initial estimates of costs for energy renovations may have been prepared for the Action Plan, confirmation of estimated costs is critical during the individual building studies, particularly as capital budget allocations will have to be made based on these cost estimates.

- Skill at evaluating the type of building. Different types of buildings may require different skills and approaches. For example, energy retrofits are sometimes performed in stages, with lighting retrofits performed first and other retrofits later. If you are doing lighting first, find auditors with skill and experience in lighting retrofits. Building size can also introduce variations: small buildings may require more creativity in developing renovations that match building function, while large buildings may be more "generic" in their requirements for some basic energy-saving measures (such as lighting).

- Skill at performing energy surveys. Knowledge of the energy systems being considered for renovation and knowledge of system interactions are important. Experience with this type of work should be carefully considered.

- Experience with evaluation of benefits. The energy audit team should be able to assess both energy and

cost benefits. The latter requires familiarity with local utility rate schedules.

- Knowledge of life cycle costing methods. If your partnership wishes specific life cycle costing methods to be used in the evaluation of economic benefits, the audit team should be capable of producing results that satisfy your requirements.

In addition to the team selected to perform the actual energy audits, serious consideration must be given to selecting a review team. This team is composed of independent energy audit experts and members of your partnership to help guide the energy audits and perform the following functions:

- Develop the most useful energy audit reporting format (see Chapter 8 for Rebuild America reporting requirements).
- Provide initial assessment of the caliber of audits being performed.
- Perform basic quality control checks on methods used for the audits.
- Perform quality control checks on audit results.

A major quality control issue that should be addressed by the review team is the specific assumptions to be used in handling utility rate schedules and in estimating the utility cost reductions (or increases) due to energy efficiency measures. Also, if the audits are performed by more than one audit team, the review team should be responsible for assuring the consistency of results and methods among audit teams. Initially, the review team should provide significant support, but as the energy audits proceed, its role should be reduced to that of maintaining quality control.

The quality of your energy audits can be enhanced by using the most qualified energy audit consultants and reviewers. As mentioned above, the more experienced members of your partnership should serve on the review team along with hired audit experts. Qualified experts and energy audit team(s) can be found through your local utilities, government energy agencies, architect/engineering firms, and local business directories. As always, using local or regional consultants whenever possible will contribute to a stronger economy in your community.

Although much can be learned by reviewing the available literature on energy audits, due to the complexity of the tasks, you will still want to rely on knowledgeable teams of both auditors and reviewers to perform your audits. The people operating and inhabiting buildings and the energy features of buildings interact in various ways to affect energy use. Some systems, especially control systems, have

complicated features and modes of operation, although some buildings are more straightforward than others. Similarly, some energy efficiency measures require more expertise than others to implement effectively. For this reason, the energy audit process should be undertaken in stages that move methodically from the simple to the complex.

Identifying Potential Energy Efficiency Measures

Once the key energy problems of a building have been identified through the energy audit, the next task is to select the most cost-effective measure or combination of measures to correct those problems. Certain energy efficiency measures tend to be implemented more frequently than others since they offer substantial energy savings, rapid paybacks, low costs, and easy implementation. Table 7 lists the most common energy conservation options in four primary building and equipment areas. Although load management is a common retrofit strategy in buildings, it is not always an energy saver and is mostly undertaken to reduce electricity demand and its associated cost. As the existing retrofit and equipment technologies improve, and as new technologies emerge, the types and installation frequencies of various retrofit measures will certainly change.

Energy savings opportunities can be found in numerous areas of any building. The areas discussed below include the building shell or envelope, lighting, mechanical systems, district heating and cooling, and operation and maintenance measures.

Building Shell

A building's shell consists of its exterior walls, roof, foundation, doors, windows, skylights, dampers, and other openings. Energy efficiency improvements to the shell typically include the addition of insulation to walls, floors, attics, and/or ceilings; window upgrades or treatments; and shell "tightening" measures to reduce air infiltration and exfiltration. Shell improvements are most critical for those buildings that have large exterior surface areas relative to their internal volumes. These buildings are primarily "shell-driven," meaning that outdoor conditions are usually the primary determinant of their energy use. Substantially higher energy bills in the winter and summer usually indicate strong weather dependence. Shell insulation is often highly cost effective for these buildings. The lower the level of existing insulation, the more cost effective it will be to add insulation. Where the ratio of shell area to interior volume is small (taller buildings with large interior volumes), internal loads dominate. In such cases, shell improvements have more limited benefits, and those are largely restricted to spaces adjacent to the external skin of the building.

Table 7. Common Energy Efficiency Measures in Retrofitted Commercial Buildings (Percentage of Retrofitted Buildings)

Lighting	Mechanical Systems
High-efficiency fluorescent ballasts (62%)	Variable-air-volume system (78%)
High-efficiency fluorescent fixtures (50%)	Air economizer (59%)
High-efficiency fluorescent lamps (47%)	High-efficiency motors (47%)
Programmable exterior lighting (44%)	Point-of-use water heaters (35%)
Task lighting (32%)	Optimized motor sizing (32%)
PL/SL-type fluorescent lamps (29%)	
Metal halide lamps (29%)	
Shell	**Load Management**
Vestibules (71%)	EMCS programmable thermostats (50%)
Thermal break windows (68%)	Curtailable-load wiring (29%)
Increased wall insulation (41%)	
Increased roof insulation (38%)	
Low-emittance glazing (26%)	

Source: American Consulting Engineers Council (ACEC 1990).

Window treatments (shading, films, screens, etc.) can be very beneficial for buildings with large glass areas facing either south or west. In the summer, especially in southern climates, solar gains through windows can dramatically increase building energy use for cooling. Window treatments to reduce solar gains can pay off rapidly, but this depends on the treatment method used. The installation of more efficient replacement windows is often too expensive an option to pay for itself through avoided energy costs. The exception is buildings with large, south- and west-facing glazing areas covering perhaps 50% or more of the wall space. In such buildings, the replacement of clear windows may be cost-justified since large solar gains through windows can account for 25% or more of the cooling load. Recent research, although limited, does show that replacement windows for tall, multifamily buildings can provide substantial energy savings if the existing windows are in poor condition (Abraham, et al. 1995).

Air sealing to minimize air infiltration can also be very cost effective (especially in taller buildings). It is important to find and concentrate air sealing efforts on the major

sources of air leakage into a building, since they can easily account for a large percentage of the air infiltration. Because mechanical ventilation systems for most larger buildings are designed to bring in outdoor air, many buildings operate under a slight positive pressure and, as a result, air leakage into the building is not a concern. If mechanical ventilation is not used, air infiltration will likely be uncontrolled and can result in significantly higher energy use. Where high humidities are present, uncontrolled air infiltration can be an even greater concern because moisture can move through building cavities, where it can be detrimental to the building's structural components and materials.

Smaller commercial buildings sometimes use unconditioned attic space as the return air path to the heating or cooling system. Such routing of return air can lead to substantial air infiltration, since return air plenums are depressurized and will suck in surrounding outside air if not sealed. In these situations, attic surfaces that have connection paths to the outdoors should be sealed (including around all pipes and other penetrations) to prevent unnecessary air infiltration. Some local codes, however, require attics to be ventilated. If this is the case, ensure that connection paths between vents and return air plenums are minimized or, preferably, eliminated. For flat, unventilated roof spaces, the addition of rigid insulation (most cost-effective during a major re-roofing) can help maintain return air temperatures, thus saving energy.

Lighting

There are several important points to remember when working to improve lighting energy efficiency: 1) do not over illuminate; 2) use efficient fixtures, lamps, and ballasts; and 3) control lighting efficiently and keep fixtures and lamps clean. Lighting levels should be tailored to the type of task being performed and the function of the illuminated space. Appropriate lighting power levels for three size ranges of new buildings are presented in Table 8. These levels were established by the U.S. Department of Energy

Table 8. Allowable Lighting Power Densities (W/ft^2)

Building Type/ Area Function	Gross Lighted Area Range (in thousand ft^2)		
	10-25	25-50	50-250
Offices	1.27	1.22	1.16
Retail	2.32	2.05	1.87
Service	1.78	1.65	1.54
Elementary Schools	1.27	1.22	1.16
High Schools	1.39	1.35	1.30
Warehouse	0.42	0.36	0.32

Source: 1994 Voluntary Performance Standards, U.S. Department of Energy.

(DOE) as voluntary performance standards (mandatory for Federal buildings) in 1994. The current ASHRAE standard (ASHRAE/IES 90.1) for energy-efficient design in new buildings is over five years old. Because lighting technology has changed rapidly, the ASHRAE standard allows considerably higher lighting levels (equal to 1988 DOE standards).

To increase local lighting levels, task lighting should be considered as an alternative to boosting lighting levels across large areas. Lighting levels can be surveyed with inexpensive light meters but the meters must be accurate and they must be used correctly to obtain accurate readings. Lighting levels should be around 50 foot-candles at the work surfaces in offices. In buildings using 4-tube, 2-ballast, fluorescent lighting fixtures, it is not unusual to find that lighting levels are more than twice what is needed—120 foot-candles or more.

Lighting surveys can sometimes enable you to decrease installed capacity by 50%, and since there is little or no capital involved, this measure can pay off rapidly. Average payback periods for typical lighting upgrades are presented in Table 9.

With the use of efficient lamps and ballasts, adequate office lighting can typically be obtained at an energy level of less than 1 W/ft^2. Lighting energy levels can be estimated in W/ft^2 by summing the rated wattages specified on the installed lamps and ballasts and then dividing by the area of the space. Generally, building spaces with appropriate lighting levels can reduce their fluorescent lighting energy use by around 25% with conversion to higher-efficiency lamps and electronic ballasts. In spaces that are highly overlit, 3 W/ft^2 or more, reductions exceeding 60% can often be obtained.

Different types of lighting are appropriate for different kinds of spaces. The type of lighting used determines achievable efficiencies, color renditioning ability, lamp life, and other important characteristics unique to specific lighting types.

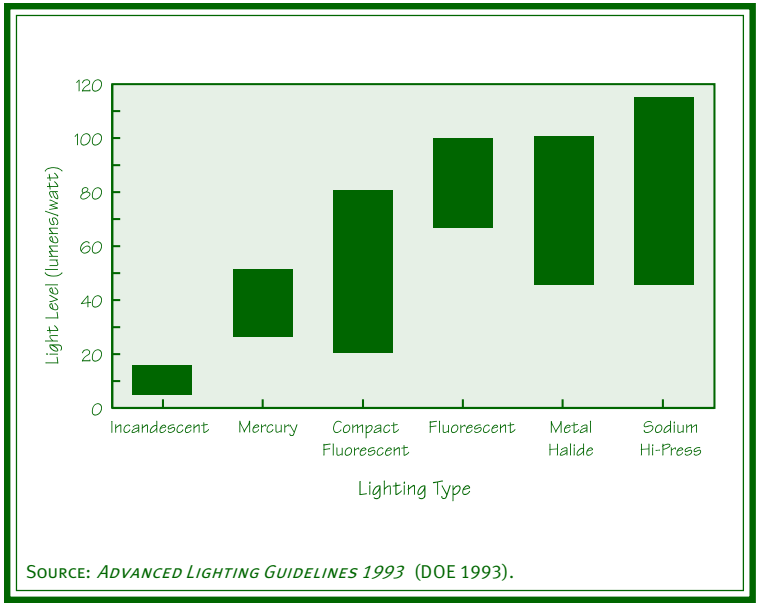
Table 9. Average Payback Periods for Lighting Upgrades

Lighting Upgrade	Simple Payback (years)
Compact fluorescent replacing incandescent	1.1 - 2.3
High-efficiency fluorescent lamp replacing standard 40W	0.5 - 1.2
High-efficiency magnetic ballast replacing standard magnetic	1.4 - 2.8
Electronic ballast replacing standard magnetic	3.9 - 8.0
Daylighting controls	1.6 - 9.6
Occupancy sensors	1.3 - 5.4

Note: Based on 3,500 hrs/yr operation, electricity at $0.07/kWh
Source: *Commercial Building Equipment Efficiency: A State-of-the-Art Review* (Geller 1988).

In some cases, requirements for any one of these characteristics can dictate the most appropriate type of lighting for a space. Popular lighting types and their efficiency ranges are shown in Figure 8.

Various methods are available to improve lighting control and performance. Subdividing a lighting system with multiple switches allows minimal lighting use during unoccupied periods or periods of low occupancy. Time clocks, occupancy sensors, and dimming controls are also popular methods for reducing lighting energy use. In addition, regular maintenance and cleaning of light fixtures and lamps will increase lighting performance and lamp life.



Source: *Advanced Lighting Guidelines 1993* (DOE 1993).

Figure 8. Efficiency Ranges of Popular Lighting Types

Lighting energy use is highly dependent on time of use, and therefore, lighting retrofit savings can be more difficult to predict in multifamily buildings than in commercial office buildings. The costs of improvements to lighting energy efficiency are easiest to justify in areas where lighting is used the most. Exterior lighting, corridors and hallways, kitchens, family rooms, and other frequently occupied areas are prime candidates.

Mechanical Systems

Opportunities for mechanical system retrofits to heating, ventilating, and air conditioning (HVAC) systems are numerous and varied due to the wide assortment of heating and cooling systems and supporting equipment used in buildings. Unlike many lighting retrofits, it can be difficult to determine the energy savings that result from mechanical system retrofits or replacements. Savings are often highly dependent on both the weather and the efficiency of the existing system (which can be challenging to measure). If the efficiency or performance of an existing system can be reliably determined, however, efficiency gains from retrofit or system replacement can often be estimated accurately. If the annual energy use of a mechanical system can be quantified, it can be used with the efficiency change to

estimate annual energy savings for a cost analysis. Numerous publications and software packages are available to assist in identifying HVAC measures and quantifying their benefits (Andrews et al. 1986, Hirst 1986, Meckler 1994, Taplin 1991, Thumann 1991, Usibelli et al. 1985, Vaillencourt 1994, Wendes 1994, Williams 1991). Some of the more popular HVAC retrofits are discussed below.

Common retrofits for maximizing mechanical system efficiencies include 1) operation and maintenance (O&M), 2) control system improvements, 3) ventilation and distribution system improvements, 4) replacement of existing equipment with higher-efficiency equipment, and 5) improvements to existing equipment.

Operation and Maintenance. O&M resources are the most common retrofits implemented in existing commercial buildings. The Lawrence Berkeley Laboratory has compiled a Building Energy and Compilation Analysis database (known as BECA) that contains information on retrofits of 292 commercial buildings. In these buildings, energy savings average 27%, and the average payback is 2.2 years (Gardiner et al. 1984). Significantly, 66% of these buildings underwent O&M retrofits.

O&M-type retrofits are popular because opportunities are abundant and these measures offer substantial reductions in operating costs, often for very little capital. Some examples of O&M-type retrofits would be periodic maintenance to keep a system operating efficiently; staging of multiple heating or cooling systems to improve part-load performance and minimize operating costs; and the use of manual cutoffs, time clocks, or setback thermostats to reduce run-times.

Control System Improvements. HVAC control system retrofits are also common. In the BECA database, HVAC control retrofits were installed in 38% of retrofitted commercial buildings. The popularity of these measures is based on their potential for rapid payback. As shown in Table 10, the Texas LoanSTAR Program found that the median paybacks for many control measures were well under 5 years (Saman 1995).

Table 10. Payback of Control Measures in the Texas LoanSTAR Program

Controls Retrofit	Number of Projects	Median Payback (years)
Chiller/chilled-water controls	8	3
Replace/install EMS	24	3
HVAC controls	60	2
Motor controls	77	4
Pump controls	11	1
Steam controls	9	4

Source: *Proceedings of the 1995 ASME/JSME/JSES International Solar Energy Conference* (Saman 1995).

Ventilation and Distribution System Improvements. Ventilation retrofits can be major savers or wasters of energy depending on how they are maintained. Economizers are often the most effective. They reduce cooling energy use by bringing in outdoor air when it is sufficient to cool the building interior. The potential energy savings can be substantial because many larger buildings, even in northern climates, operate in a cooling mode year-round due to internal heat gains from people and equipment. In office buildings, cooling energy consumption can be reduced by 10 to 50%. If economizers fail, however, and go unrepaired, they can be major energy wasters. Depending upon the vent position at the time of failure, they can bring in large amounts of cold, warm, or very humid air during the times of year when it is least desirable.

In distribution systems, distributed steam or hot water temperatures are often significantly higher than necessary to support the maximum load on the system, often resulting in excessive air temperatures in some areas of the building. Excessive distribution media temperatures cause increased energy use. In many cases, the temperature of the distribution media can be lowered substantially, yet still meet the maximum load on the system. Since this is a relatively inexpensive measure, rapid paybacks can be obtained. In large hot water distribution systems, opportunities for reducing the volume of pumped water can also save energy. Conversion of constant-air-volume distribution systems to variable-air-volume has attractive paybacks and has also recently increased in popularity.

Equipment Replacement. HVAC equipment at or near the end of its useful life should be considered for replacement with equipment that operates efficiently at both design and part-load operating conditions. For example, most older boilers seldom operate at their rated output. Replacement of such boilers with smaller, high-efficiency, modular (multiple) boilers can boost seasonal efficiencies by 5 to 10% or more. Replacing existing electric resistance heating systems with heat pumps or other systems that are more efficient or use lower-cost fuel can also provide substantial energy savings.

The replacement of existing cooling equipment with higher-efficiency equipment can also provide attractive paybacks. High-efficiency, direct-expansion cooling units (referred to as packaged or split systems) can be twice as efficient as older systems with standard efficiencies (Geller 1988). The energy efficiency ratio (EER) of the new system divided by that of the old yields an indicator of how much more efficient the new system will be. Higher-efficiency chillers also significantly outperform older systems and meet current U.S. (non-CFC) refrigerant requirements. Chiller coefficients of performance (COPs) can be compared as an indicator of potential energy efficiency gains.

During the replacement or conversion of a chiller is an opportune time for considering upgrades to all building energy systems related to cooling or affecting cooling load. Installation of efficiency chiller systems rather than simple conversion or replacement with units that meet minimum efficiency criteria can be an important energy-saving upgrade.

Reducing cooling loads can enable you to "downsize" your chiller, which will save energy and costs. Cooling loads can be reduced through high-efficiency lighting upgrades, building shell improvements, or other measures. The savings associated with purchasing a smaller chiller may allow a building owner to buy a more efficient model. Savings from lighting or other upgrades could also be used to help offset the extra cost for a more efficient replacement chiller. Another way to reduce new chiller size and cost is to also install new, more efficient HVAC auxiliaries (e.g., evaporative cooling towers, coils, variable-speed drives). Alternatively, you can look for ways to improve the efficiency and operation of auxiliary chiller components, including distribution systems.

Equipment Improvements. As an alternative to replacing existing equipment, there are numerous retrofit options, including O&M measures. For example, capturing rejected heat is a relatively new retrofit approach that is catching on quickly due to attractive energy savings and rapid paybacks. For fossil-fired heating systems, heat can be recaptured by condensing exhaust gases (this captures most of the heat that normally is exhausted through the flue). Heat recovery from building exhaust air streams is also becoming very popular. The recovery is accomplished through heat exchanger coils, heat wheels, and air-to-air heat pipes. In steam systems, the capture of condensate return is essential for efficient operation.

District Heating and Cooling

District heating and cooling (DHC) systems supply energy to about 10% of commercial floorspace in this country. Connection to these systems is an option for supplying heating and cooling needs to some buildings. The thermal energy is generated in a central plant and is provided to the consumer through a network of distribution pipes. This eliminates the need in the building for primary heating and cooling equipment, the associated floorspace, and the equipment operators. Up to 50% primary fuel (and air emission) savings can be realized if the DHC thermal energy is produced in an electricity cogeneration plant. The cost of constructing and maintaining a DHC system must be balanced against the cost of owning and operating individual building primary heating and cooling equipment. Because of this, DHC systems tend to be located in high-energy-use, high-density urban areas and multi-building facilities (including educational facilities).

DHC systems offer the advantage of fuel and energy resource flexibility, which can provide greater reliability to customers. Typical costs of heating energy delivered to a building can range from $6-12 per million Btu. Connection to district cooling systems may be desirable during a building rehabilitation, since the existing CFC chillers must either be replaced or retrofitted in non-CFC refrigerants. Typical connection charge to a central chilled water systems is about $90 per ton cooling capacity, which is about 10% of the installed cost of a water chiller. Typical costs of chilled water delivered to a building can range from $12-25 per million Btu. Central cooling systems are well suited for controlling refrigerant emissions and can cost-effectively produce chilled water using technologies that do not use ozone-depleting refrigerants. DHC systems can also provide a greater reliability by having a diversity of consumer loads, standby central plant equipment, and a full time operating staff. In addition, these systems can help balance the peaks and valleys of electric and thermal demands through the use of thermal storage and non-electric chillers.

A number of measures can be taken to increase the energy efficiency of existing DHC systems. However, it should be remembered that DHC systems are capital intensive, and the energy savings cost reduction must balance against the cost of the measures. Many of the measures could become attractive when the existing system needs repair or expansion.

Changing the existing central energy source to a cogeneration plant leads to fuel and emission savings, as stated above. Thermal losses from the heat distribution network can be reduced by lowering the network operating temperature. Leaks and pipe insulation failure also reduce the efficiency of the distribution network. For steam and hot water systems with temperatures above 250 degrees Fahrenheit, relocating the distribution pipes to dry areas, such as tunnels or shallow trenches, can reduce pipe and insulation failures. Use of hot water systems with temperatures below 250 degrees Fahrenheit has many advantages and should be considered when replacing or expanding an existing system. Staged, variable-speed pumps can greatly reduce electrical energy consumption in hot water and chilled water systems, and they can reduce the chiller energy requirements in chilled water systems.

Planning for connection to an existing or a new DHC system will usually require long lead times, particularly for a new DHC system. There are many stakeholders in this undertaking, among whom are the system developer, the building owner or manager, the governments and their regulatory agencies, the competing utilities, and the financial institutions. All stakeholders must agree on expected capital costs and energy costs to be charged to the users before the system construction actually begins.

Operations and Maintenance

In some cases, the best retrofit measure may be to institute a preventive maintenance program. Any number of situations may make this measure highly cost effective. Systems may have been poorly designed or installed improperly, or building use may have changed over time due to shifts in occupants or alterations to the structure. Building managers and operators are faced with a vast array of designs, computerized technologies, information systems, organizational changes, and management issues. Budgets are frequently too restrictive to allow adequate documentation of procedures or training of staff, particularly in the use of computerized control systems and computerized maintenance management tools. The collection and reporting of information about criteria, performance, and results of proper operation and maintenance are often given low priority, and the necessary information never reaches the decision-makers.

For any or all of these reasons, a building may not be operating as efficiently as designed. When the gap between current operations and design is significant, simply bringing a building up to design level may result in significant energy savings. The cost effectiveness of this approach will depend upon the measures required to make the needed improvements (how much they affect energy use and how much they cost). Several helpful documents are available to guide you through the process of developing a strong operation and maintenance program or scheduling preventive maintenance activities. A few references are listed at the end of this chapter (Thumann, Taplin, ASHRAE 1995).

Integrating Measures

One approach to selecting energy efficiency measures is to consider load-, system-, and plant-level savings opportunities in strict progression. Proponents of this approach cite the multiplier effect that can be achieved if plant-level equipment can be significantly downsized as a result of reduced energy requirements at the load and systems levels. Replacement chillers at the plant level, for example, could be significantly downsized if the building's thermal load and system inefficiencies were reduced. (In commercial buildings, for example, more energy-efficient office equipment could lower the load and simultaneously reduce cooling requirements.) Where capital is limited, however, this approach will not necessarily achieve the greatest energy and cost savings.

Consider energy use impacts on the entire building.

Regardless of the particular energy efficiency measures and building upgrades being considered for your stock, it is essential that your team consider the energy use impacts on the entire building. In implementing the upgrade of a single building component, the component is often evaluated upon its own merits, and its impacts on other energy end-use loads are overlooked. This omission

can lead to disappointing overall results. The building, its equipment, and occupants are all major determinants of energy use. In addition, they all interact with and can strongly influence one another. Thus, the impact on the building as a "system" must be assessed for any individual or combination of upgrades.

Two examples will serve to illustrate how major interactions can occur between building components. The first example examines potential interactions between lighting improvements and mechanical equipment. Lighting improvements generally lower lighting-generated heat within the building. As a result, cooling energy use will typically decrease and heating energy use will increase. Since overall cost benefits are highly dependent on heating and cooling system efficiencies and fuel costs, dramatic cost benefits might occur in one building, while another building with high heating costs might achieve only half of the predicted savings.

The second example concerns the interaction between mechanical system upgrades and improvements to the building shell. In some cases, upgrading the heating or cooling system while simultaneously adding insulation can dramatically decrease the savings that might have otherwise been gained from the addition of the insulation alone. In this scenario, either measure alone could be cost effective, but the second measure would deliver less benefit per dollar of investment. This illustrates the value of examining overall building energy impacts.

Planning and Prioritizing Measures

A variety of factors should be considered in planning or prioritizing the installation of energy-saving measures. Some situations may serve as "triggers" to expedite installation, while others may support deferred action (e.g., timing of equipment upgrades to coincide with scheduled renovations in the same area of a building). Several of these situations are discussed below along with the associated opportunities.

Funding Availability

Many public and private organizations regularly fund some or all of their energy efficiency improvements from current operating revenues or through direct debt financing. In general, funding through such internal sources provides two clear benefits—it returns all savings to the organization, and it is usually the simplest and quickest option administratively. However, even if internal funds are constrained, the lack of investment capital should not be cited as a major obstacle to the implementation of sound energy efficiency improvements to buildings and facilities. Capital for energy efficiency improvements is easily available from third parties through a wide range of flexible financing instruments. Three common means for obtaining such outside financing are lease or lease-purchase agreements, energy savings performance

contracts, and incentives available through utility demand-side management programs. A more detailed discussion of funding sources can be found in Chapter 4 of this handbook under Funding Issues.

New Construction/Major Rehabilitation

New construction and building rehabilitation are particularly opportune times to incorporate energy efficiency improvements. Making efficiency improvements during construction or rehabilitation can significantly reduce the cost of improvements (as compared to the cost of later retrofits). As a result, improvements that may not be possible or cost effective in a retrofit situation, may become viable. It is generally not possible, for example, to perform a major upgrade of energy efficiency, such as the addition of insulation to a wall, to an occupied commercial building. As part of a planned rehabilitation effort, however, the measure can be easy to install and therefore becomes a very cost-effective option.

Environmental Incentives

There are several environmental incentives that might induce building owners or occupants to install new equipment, more efficient equipment, or both. Examples of such inducements include the hazardous PCBs that are present in some older fluorescent lighting ballasts and the emissions from fossil-fired heating systems or electric generating stations, which are increasingly regulated and monitored. In many cases, the cost of a failure or the cost of compliance will begin to equal a substantial part of the cost to replace the system.

The mandated halt to production of ozone-destroying CFCs will force many building owners to consider such cost trade-offs if they have not already. A large portion of the chiller stock in the nation depends on CFCs as refrigerants, but CFCs will become increasingly difficult and expensive to obtain (after January 1, 1996). Unless an inexpensive CFC-replacement refrigerant can be developed and put on the market, chiller conversion or replacement with models that use some other non-CFC fluid may be the most desirable alternative.

There are about 80,000 chillers providing building cooling in the United States, and most of them were designed to use CFC refrigerants. As of late 1995, about 10,000 CFC chillers had been recently replaced or converted to use non-CFC refrigerants, but relatively little had been done about the remaining units.

System Failure

Impending system failure is an excellent time to look at energy efficiency. This is because expenditures are going to be required anyway—unless the system is no longer needed. The decision becomes whether to use these expenditures to repair an antiquated, worn, or inefficient system or apply them toward the purchase of a new, more energy-efficient system. The new system will offer sizeable annual energy savings, reduced maintenance costs, and longer life. If the annual fuel use and efficiency of a system is known, the energy savings resulting from the installation of new, higher-efficiency equipment can often be easily estimated. These annual energy savings can often tip the economic scales toward the purchase of a new system.

Depending on the failure mode, system replacement may be the only option. The additional cost of the more energy-efficient equipment should be looked at closely in this case. Often, the additional cost of more efficient equipment can be paid off rapidly by the resulting energy savings.

References

Abraham, M.M. et al. 1995. *Energy Retrofits Installed in the Margolis High-Rise Apartment Building,* Chelsea Housing Authority. Oak Ridge, TN: Oak Ridge National Laboratory, ORNL/CON-413.

ACEC. 1990. Amerrican Consulting Engineers Council, Washington, DC, 202-347-7474.

Andrews, J.W, et al. 1986. *Triage of Oil and Gas Retrofits for Residential/Light Commercial Heating Systems.* Long Island, NY: Brookhaven National Laboratory, BNL-38090.

ASHRAE 1995. *1995 HVAC Applications Handbook.* Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers. Chapters 32-39.

ASHRAE/IES. 1989. *Energy Efficient Design Of New Buildings Except New Low-Rise Residential Buildings.* ASHRAE Standard 90.1-1989. Atlanta, GA: American Society of Heating, Refrigerating, and Air-Conditioning Engineers.

Code of Federal Regulations. 1994. *Energy Conservation Voluntary Performance Standards For New Buildings; Mandatory For Federal Buildings*, Code of Federal Regulations Number 10, Part 435. Washington, DC: Office of the Federal Register, National Archives and Records Administration

DeCicco, et al. 1996. *Improving Energy Efficiency in Apartment Buildings.* (Available from the American Council for an Energy Efficient Economy, 2140 Shattuck Ave., Suite 202, Berkeley, CA 94704, Phone: 510-549-9984)

DOE, et al. 1993. *Advanced Lighting Guidelines.* Available from OSTI and NTIS, DOE/EE-0008.

Gardiner, et. al. 1984. Measured Results of Energy Conservation Retrofits in Non-Residential Buildings: An Update of the BECA-CR Data. *Proceedings from the ACEEE 1984 Summer Study on Energy Efficiency in Buildings*, Vol. D, 30-48.

Geller, H. 1988. *Commercial Building Equipment Efficiency: A State-of-the-Art Review.* Washington, DC: American Council for an Energy Efficient Economy, A882.

GSA. 1994. *Energy Management: A Program to Reduce Cost and Protect the Environment.* U.S. General Services Administration and the Electrification Council (202-508-5900).

Hirst, E. et al. 1986. *Energy Efficiency in Buildings: Progress and Promise.* Washington, DC: American Council for an Energy Efficient Economy.

Meckler, M. 1994. *Retrofitting Buildings for Energy Conservation.* Atlanta, GA: Association of Energy Engineers.

Newnan, D.G. 1977. Engineering Economic Analysis. San Jose, CA: Engineering Press.

Saman, N.F., et al. 1995. Empirical Correlations between Annual Cost Savings and Implementation Costs for Various Categories of Energy Conservation Retrofit Projects in Commercial Buildings. *Proceedings of the 1995 ASME/JSME/JSES International Solar Energy Conference.* Maui, HI.

Thumann, A. 1991. *Plant Engineers and Managers Guide to Energy Conservation.* Atlanta, GA: Association of Energy Engineers.

Taplin, H. 1991. *Boiler Plant and Distribution System Optimization Manual.* Atlanta, GA: Association of Energy Engineers.

Usibelli A. et al. 1985. *Commercial-Sector Conservation Technologies.* Berkeley, CA: Lawrence Berkeley Laboratory, LBL-18543.

Vaillencourt, R.R. 1994. *Simple Solutions to Energy Calculations.* Atlanta, GA: Association of Energy Engineers.

Wendes, H.C. 1994. *HVAC Retrofits: Energy Savings Made Easy.* Atlanta, GA: Association of Energy Engineers.

Williams, A.F. 1991. *Software Applications and Directory for Energy Analysis.* Atlanta, GA: Association of Energy Engineers.

7 How to Implement Your Program

At this point, you and your partners should have identified a set of energy-saving opportunities for your candidate buildings as well as numerous potential measures for capitalizing on those opportunities. If all of these energy-saving measures were to be implemented, the resulting energy and cost savings would easily exceed the goals of your partnership. As you proceed with the detailed planning, analysis, and design, however, the list of measures to be implemented will be pared down and refined.

This chapter provides advice and suggestions to guide your energy team through the implementation process. As shown in Figure 9, there are six main stages to the process:

Planning for Implementation. The energy team for implementation will need to plan and coordinate a vast array of activities to successfully guide the retrofit program. The plans should establish robust reporting and

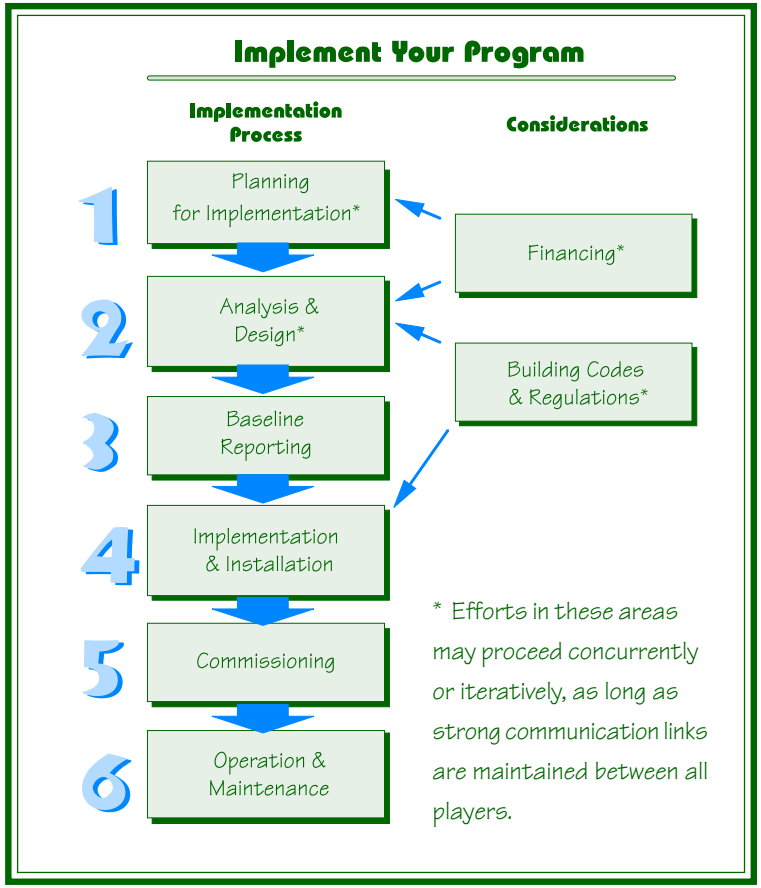


Figure 9. The Implementation Process

communications procedures, set reasonable schedules, and incorporate strategies for handling contingencies.

Analysis & Design. The technical accuracy of the on-site engineering analysis and the resulting design and specification of measures should be of the highest caliber, as the ultimate success of the retrofit effort hinges on these elements.

Baseline Reporting. Prior to implementing any of the selected measures, your partnership should check that it has accurate baseline measurements of current energy performance in the selected buildings. These measurements will be important later in assessing the energy benefits of your program.

Implementation/Installation. The attention to detail in the analysis and design stage must be carried forward to ensure that the retrofit measures are installed as designed. Equipment and materials must be carefully selected according to specifications and should be inspected during installation.

Commissioning. Rebuild America strongly encourages its partners to incorporate commissioning in their retrofit plans. By verifying the correct installation, functioning, operation, and maintenance of equipment, the commissioning process ensures that the installed measures will continue to deliver energy benefits for the long term. Commissioning can take place after the measures have been installed, but is more effective when it encompasses the entire retrofit process from planning through operation and maintenance.

Operation and Maintenance (O&M). The energy and cost benefits of your retrofit program will extend over a longer period if the measures are correctly operated and maintained by a trained staff. Successful commissioning will also facilitate this process.

In practice, the first two stages may be addressed simultaneously or even iteratively, depending upon the mix of skills on your team. Whatever the order in which they are undertaken, however, each of the stages entails a number of steps, options, precautions, and decision points that must be considered in the implementation process. These issues are discussed in the first part of this chapter. As shown in Figure 10, other considerations must also be taken into account. For example, the cost estimates and financing strategies (discussed in Chapter 4) should be revised and refined. The second part of this chapter discusses another important consideration—the implications of building codes and regulations.

The Implementation Process

Before implementing your program, you will want to make sure that you and your partners have a clear understanding of the goals and objectives, a commitment of staff and resources, and a clear sense of why the work is important. Since there are no "cookbook" approaches to most retrofit activities, a shared sense of

purpose and clear communications between all players are critical to fostering the individual initiative and perseverance that will be necessary to see the project through completion.

The energy team members for this phase of the work will handle the efforts necessary to select and install the efficiency measures and ensure that they operate properly. Ideally, the energy team will have people dedicated full-time to the work. Even if some members are only available on a part-time basis, however, everyone should recognize that all team members are vital to the task. In addition to the team leader, the team should have a field engineer familiar with retrofit design and implementation as well as a staff member who is knowledgeable about financing of building retrofits. Other team members could include local utility staff and consultants from the energy community. Often, building owners or managers will serve on the team as well.

Caution is advised when considering private service companies or suppliers (including ESCOs, equipment vendors, contractors, and architects/engineers) as team members or even as partners. If you are interested in teaming with an organization of this type, you may first want to establish a clear agreement as to their role in order to eliminate the potential for a conflict of interest. For example, if engineering services will be competitively sought for each building being retrofitted, then your team engineer could be instructed to exempt his or her firm from bidding such services.

Planning for Implementation

There are a large number of technical and management considerations that need to be addressed for each stage of any retrofit project. It is the responsibility of the energy team for implementation to account for all of these factors at the beginning of the project so that sufficient resources and staff can be allocated and work will not be held up because of a lack of support at a critical juncture.

The entire retrofit implementation process will proceed more smoothly if the energy team places a high priority on coordinating the actions of all players and establishing sound reporting and tracking practices. Most building retrofits are complex operations involving the coordination of actions by diverse groups of individuals under demanding schedules. It is extremely important that your team establish a schedule that meets the needs of the building owner(s) and occupants and is reasonable in terms of the time allotted for the delivery and installation of all retrofit measures. In addition to the usual delays inherent in any building construction, retrofit projects often suffer from "unseen" delays caused by problems that crop up during the project. Asbestos removal, disposal of transformers that are leaking PCBs, and other remedial environmental activities can be accommodated if contingency plans are developed at the outset.

As in any activity, clear communication about the state of the work is extremely important and all parties need to

In establishing your retrofit schedule, consider the impacts on building occupants and owners.

be informed on a regular basis. Daily and weekly meetings (as needed) can insure that nobody is left out of the information loop.

In addition, careful tracking of all costs and activities will serve to document the effectiveness of the retrofits—information that may be useful in convincing others that the work is worth doing. Something as simple as having a central file cabinet with the documentation for each project can make the whole activity go more smoothly. Good computer records can significantly enhance reporting on progress and may assure that future work is approved more easily. While some information may seem trivial at the time, careful records of all expenditures and activities may provide the information necessary to later obtain support for additional retrofit projects.

Insofar as possible, the team should strive to develop an implementation plan that is both detailed and farsighted. This will avoid the "if only we had ..." syndrome later in the process. Revisions to the plan are to be expected as work proceeds, but major decisions should be made as early as feasible. Before moving from the planning stage, your team should make sure that the planned program addresses all of the considerations raised in this handbook. For each step, the plan should address the approach that the partnership will take, the responsibilities of the various team members, the sequence and approximate schedule of key events, and the resources to be used in each of the stages. Much also can be learned from recent energy retrofit projects or programs in your locality. Your local utilities and government energy agencies can assist you in this area.

2 Analysis and Design

The design of any retrofit activity should be viewed as an opportunity to improve how a building works. Whether the retrofit measure consists of new windows, better lighting systems and controls, or better control of the HVAC system, it should not only save energy but enhance the well-being and comfort of the building's occupants. Any retrofit design affecting the appearance and environment of a building, such as lighting replacement, should carefully consider the needs and preferences of the occupants, the building management, and the owners. Moreover, the measures included in a design must be carefully selected, tailored, and integrated to effectively correct the existing problems in building performance.

The analysis and design stage demands a high level of technical competence. The on-site engineering analyses require individuals with extensive, in-depth technical knowledge of building system components and the varying effects produced through the interaction of these components. It is also essential that such persons be capable of preparing highly specific and complete project documentation and specifications. Members of your team may have the requisite professional skills, but in most cases you will also need to contract for

the services of an energy engineering consultant. These consultants can be found through your local utilities, government energy agencies, architectural firms, or local business journals.

Engineering Analyses. Detailed on-site engineering analyses must be conducted to develop costs and estimates as well as specifications for each retrofit measure. Separate analyses are particularly important if you are evaluating several alternative measures. This work can be performed by a qualified energy consultant as described earlier. This consultant employs several tools to assist in the identification and analysis of potential energy measures, such as sophisticated energy audit techniques and energy metering/monitoring instruments (for use on site), computerized building energy simulation programs and design models, customized electronic spreadsheets, and equipment sizing programs. The engineering consultant will also confirm the costs (and potential savings) of the various retrofits being considered, and can recommend which sets of measures are most appropriate for your buildings.

Engineering Documentation and Specifications. At a minimum, the documentation from the engineering analyses should include the results, a complete description of each recommended retrofit measure (e.g., "T-8 lamps with electronic ballasts" rather than just "energy-efficient lighting"), and the savings predicted for each measure. Specifications for the retrofit measures can be prescriptive or performance-based and should also typically include complete installation guidelines and warranty information. The warranty information should be consistent with the assumptions in the economic analysis regarding the service life of each measure. In addition, the specifications should indicate the time period in which the work must be performed, applicable local building codes (discussed later in this chapter), and any related concerns. Remember that specifications should be specific, but not to the extent that they would preclude changes or alterations. A page from a sample specification for the retrofit of window films is provided in Figure 10.

For complex retrofits, such as energy management control systems (EMCSs), the specification should include the functions needed so that the bidders can select and propose their best equipment for the application. For other retrofits, such as lighting replacement, the specifications can identify either the specific equipment desired or the performance criteria (e.g., Watts per square foot for a desired illumination level).

3 Baseline Reporting

Now that your partnership has clearly defined the energy efficiency measures to be implemented in selected buildings, you will want to make sure that you have an accurate picture of how much energy is being used in those buildings prior to retrofit. These data will give you a baseline against which to measure future energy use and thereby assess your energy savings.

SECTION 12525
SOLAR CONTROL FILM RETROFIT

PART I - GENERAL

1.01 SECTION INCLUDES
- A. Removal of old solar control film
- B. Installation of new solar control film
- C. Material specification

1.02 RELATED SECTIONS
- A. Division 1: General Requirements
  1. Section 01010, General Requirements
  2. Section 01210, Special Provisions

1.03 PROJECT DESCRIPTION
- A. The Building is a non-laboratory science, engineering, and office building comprising approximately 8500 square feet of glazing on four above grade levels and three sides.
- B. Approximately 75% of the window surfaces on the south and east elevations have been filmed at undetermined times.
- C. The work will be to remove the old film and install new film.

1.04 SUBMITTALS
- A. Pre-Construction Submittals
  1. Submit product data for manufactured products.
  2. Submit manufacturer's installation instructions.
  3. Submit proposed material delivery and film installation schedule.
- B. Submit manufacturer's maintenance (care and cleaning) instructions.

1.05 QUALITY ASSURANCE
- A. Qualifications
  1. Manufacturer: Company experience in manufacturing the product specified in this Section with minimum five years documented product development, testing, and manufacturing experience.
  2. Installer: Subcontractor experience in applying the work of this section with a minimum five years documented experience. The installing subcontractor shall provide evidence of 6 month's employment with the subcontractor for each installer used at the site. Independent Contractors working for the subcontractor do not qualify as employees.
  3. The subcontractor shall furnish all labor and materials to remove the old film and accomplish installation of the new film.
  4. The subcontractor shall have a complete sales, installation, and service operation within 70 miles of the site.
  5. Subcontractor must be licensed for C-17 (glazier) or C-61 (specialty-film).

- B. Pre-Start Meeting
  1. The subcontractor shall convene a conference with the building and project managers after award but prior to making submittals.
  2. The subcontractor shall require attendance of all employees directly performing the work of this Section.

1.06 DELIVERY, STORAGE, AND HANDLING

Material, tools, and equipment are the responsibility of the Subcontractor. The owner will not be responsible for storing or handling any Subcontractor supplied tools, equipment or material.

1.07 WARRANTY
- A. Provide a 10-year manufacturer's warranty on film and a 10-year warranty on installation.
- B. Warranty shall fully cover material and labor costs to remove and replace defective film without proration.

Figure 10. Sample Specification

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Film [product name] or equal.
B. Substitutions will be considered: See Sec. 01010-1.08 for requirements.
C. Substitutions will not be considered without separate written request (in triplicate).

2.02 FILM PERFORMANCE

A. Visible light transmissibility (Tv) shall be greater than 0.65. Tolerance for Tv is to be held to plus or minus 2% of the published value, from edge to edge.
B. Shading coefficient (SC) shall be less than 0.55.
C. Visible light reflectance both sides shall be less than 0.10.
D. Ultra-violet transmissibility shall not be greater than 4%.
E. Thickness shall be a minimum of 1.5 mils (without release liner).
F. The inward facing surface shall have a factory applied, optically clear, abrasion resistant coating sufficient to protect against optical hazing as a result of washing and wiping.
G. The films metallic coating shall be free from visible streaks, banding or pinholes. The film color shall be uniform in density from edge to edge.
H. The film shall have a factory installed, optically clear adhesive, protected with a silicone coated polyester release liner.

PART 3 - EXECUTION

3.01 SCHEDULE

A. Elevation Orientation

Approximate Building Square Feet	West	South	East
1st Floor	416	1,456	423
2nd Floor	439	1,593	447
3rd Floor	439	1,593	447
4th Floor	324	842	94
	1,618	5,484	1,411

B. South and East elevations shall be used to calculate the "Base Bid". The West elevation shall be used to calculate "Additive Alternate 1."
C. All work shall be scheduled for performance outside the normal workday of 8 a.m. to 5 p.m. Monday through Friday, and the bids calculated accordingly.
D. The moveable portion of exterior glass doors has not been included in this footage and the doors are not intended to be covered by this project.

3.02 OLD FILM REMOVAL

A. Remove all old interior film and razor clean the glass using a [brand name] glass cleaning razor.
B. Remove all traces of old film and/or film adhesive, then rinse and squeegee the entire surface of the window using a solution of filtered water and a lubricating solution as recommended by the film manufacturer.
C. Wipe dry and clean the entire window area perimeter.

3.03 NEW FILM INSTALLATION

A. The Subcontractor, within 1 week of award, shall provide in writing a pre-planned schedule of installation, identifying each space requiring entry. The preferred format is a Gantt Chart, a horizontal bar chart of time dependent elements of performance.
B. Where glass has been free of prior film treatment, razor clean the glass using a [brand name] glass cleaning razor.
C. Rinse and squeegee the entire interior surface of the window using a solution of filtered water and a lubricating solution as recommended by the film manufacturer.
D. Wipe dry and clean the entire window area perimeter.
E. Apply film to the glass and remove excess moisture from under the film using two complete passes with a slab urethane squeegee. Trim the film to fit uniformly 1/8 inch from the edge of glass panes.

Figure 10. Sample Specification (cont.)

These energy data elements will also be required later for the reports to be submitted to Rebuild America (as discussed in Chapter 8). At a minimum, you should have the following totals:

- Total monthly energy use for electricity (kBtu)
- Total monthly energy use for fuels other than electricity (kBtu)
- Total monthly energy cost by fuel type
- Start and end dates of time period
- Total square feet of each commercial building
- Number of multifamily dwelling units per building (and square footage of a typical unit, if available)

Whereas your earlier data collection efforts may have encompassed a broad range of candidate buildings, it is best to have these energy measurements correspond as closely as possible to the actual areas (square footage in commercial buildings or number units in multifamily buildings) that will be affected by the retrofit program.

4 Implementation/Installation

The attention to technical accuracy and detail in the analysis and design stage will be enormously helpful in the implementation stage. Care should be taken to avoid losing any important details in the bidding and negotiating process. Similarly, knowledgeable supervision and inspection of the installation work will help to ensure that the installed measures perform as intended.

Bidding and Contracts. Once the engineering analyses have been completed and the measures have been shown to be economically justified, you will need to request bids or proposals for equipment procurement and for work that you cannot perform with internal staff alone. These processes will differ by the type of organization (public or private sector) that will carry out the project, the range of energy efficiency measures desired, the nature of equipment and services desired, the sources of financing, and any current procurement restrictions on your organization or partnership.

Competitive procurement processes are generally designed to obtain the best price and value for a defined set of equipment and/or services. In most cases, a competitive procurement process starts with the development and release of a formal Request for Proposals or a more general Request for Qualifications. Selection of a vendor for the desired equipment or services is made by evaluating responses to

the formal request in a manner that balances lowest price against other merits, including the vendor's prior experience, responsiveness, reputation, and equipment or service warranties.

The nature of the procurement process is likely to differ significantly between well-defined projects that you are planning to finance with internal resources and more broadly defined projects that you may consider implementing through third parties, such as energy service companies. While competitive procurement processes are recommended for both types of projects, a "Request for Proposals" is generally used for the former, while a "Request for Qualifications" is recommended for the latter.

- Request for Proposals. This instrument is recommended when specific equipment and/or service needs are known and well defined. For example, using a Request for Proposals is recommended if you have conducted a detailed energy audit on a building, identified specific measures and equipment needs as a result of that audit, and know any other services (e.g., a defined level of continuing operations and maintenance or leasing arrangement) that will be required.

- Request for Qualifications. This instrument is recommended when you have defined general opportunities for energy efficiency improvements, but have not designed specific measures, and when you are seeking a third-party energy service company (ESCo) to design, install, and finance measures that capture the energy savings opportunities. In most cases, the proposed cost of energy efficiency improvements cannot enter into the selection of an ESCo since specific improvements cannot be defined until the ESCo is selected and performs its own energy audit.

Both of these procurement processes can be designed to satisfy the competitive requirements established by most public or private sector organizations. Evaluation and selection criteria for the former can easily be designed to include rankings according to lowest price. Evaluation and selection criteria for the latter must be based on factors that predict performance and value based on qualifications, including prior experience, technical approach, financing approach, project management capabilities, and performance guarantees.

For some retrofits (such as EMCS systems), partial completion is not acceptable for partial payment; to ensure the performance of such measures, payment should be withheld until 100% of the work has been completed. Withholding payment until all work is completed has the additional benefit of encouraging contractors to stay on schedule. For other retrofits, such as window or lighting retrofits, partial payment can be made upon partial completion since the success of the whole project does not depend on the completion of all the work. Careful

construction management and inspection will be needed in any case to prevent shortcuts and deletions that could reduce the performance of the retrofits.

Construction Management and Inspection. The degree of construction supervision and inspection will depend on the size of the project, but supervision of even the smallest projects should include the following elements to ensure quality:

- Verify that the equipment and materials installed match the specifications, particularly if substitutions have occurred.
- Confirm that the actual installation of the measures conforms to all applicable building codes and regulations for your locality (discussed later in this chapter).
- Check that all operating manuals are in place and warranty information is in order.
- Maintain close communications between owner, tenants, and contractors about any changes that might affect the schedule and the use of the building.

5 Commissioning

Commissioning is the process of systematically evaluating building equipment, subsystems, and operation and maintenance procedures, as well as the performance of all building components to ensure that they function efficiently as a system. Moreover, commissioning helps to make sure that a building or facility provides a safe, efficient, and comfortable shelter conducive to the activities for which it is used. Some of the benefits of commissioning are as follows:

- Better building operation. Commissioning assures that all retrofit specifications and drawings are updated to reflect actual modifications to the building ("as-installed") and that all O&M manuals have been delivered and can be easily understood by those who must use them. Commissioning provides operation and maintenance personnel with the knowledge and training to operate building equipment properly, schedule activities that maintain and extend equipment life, and generally perform their responsibilities in a manner that will increase operational savings.
- Improved design and construction. Commissioning can result in greater cooperation among the professionals involved in the retrofit and permit a cross-check of the performance of a building's equipment and combined systems. This ultimately results in fewer callbacks and fewer construction litigation problems.
- Tenant retention. Commissioning can improve indoor air quality and make a building healthier, safer, and more comfortable.

Commissioning Case Studies

Three recent projects indicate the energy savings that can be achieved through commissioning.

Project 1. Commissioning was applied to a 25-building corporate facility including offices, research facilities, and housing. The facility contains 7 million square feet with an annual utility cost of approximately $12 million. Since 1992 the corporation has implemented commissioning strategies and instituted training and data collection to measure building performance. Annual savings have resulted in a one-year payback. Further savings are expected as additional savings opportunities are pursued (Herzog 1995).

Project 2. The HVAC system of an 84,000-square-foot office building in Rockville, Maryland, was upgraded in conjunction with a building tune-up as part of the EPA Energy Star Buildings Program. The project was commissioned to ensure savings. Capital costs for the upgrade and commissioning were $1.82 per square foot. For this investment, annual energy costs were reduced by $1.07 per square foot per year, and the asset value of the building increased by $8.82 per square foot, providing an internal rate of return of 59% (EPA 1995).

Project 3. In a Pacific Northwest office building, commissioning of supply air controls, zoned lighting sweeps, an energy management control system, and daylighting controls yielded significant savings. The building owner and occupants also benefited from improved operation and maintenance, increased equipment life, and improved comfort and indoor air quality (IAQ). The cost for this project was $1.46 per square foot and the measures yield an annual savings of $4.34 to $4.47 per square foot (BPA 1994).

- Greater budgeting accuracy. Commissioning oversight of retrofits generally results in projects that are on-time and within-budget.

At least three different approaches can be taken to commissioning. It can be implemented following installation, incorporated throughout the retrofit process, or used alone as a means to improve building energy efficiency. During the planning phase, you or your team will need to decide on the level of commissioning appropriate for your program.

The Rebuild America program recommends that its partners implement some form of commissioning. At a minimum, every retrofit program is encouraged to commission its buildings once the retrofit measures have been installed to ensure their correct and efficient operation.

Every retrofit program is encouraged to commission its buildings to ensure their correct and efficient operation.

- Reduced liability. Commissioning can result in fewer complaints and tenant actions related to construction, and can lower the risk of post-construction legal action stemming from conditions such as indoor environmental pollution.

Commissioning is most effective when initiated at the planning stage, when renovation or retrofit is under consideration. If handled in this manner, before conceptualizing the design, a preliminary meeting helps each member of the project team understand the goals and procedures of the

commissioning process. The building owner, the architect, the engineer, the contractor, and the commissioning agent can make plans to integrate the building's performance with its functions. The commissioning agent can point out effective means for achieving energy efficiency, cost savings, and long-term reliability.

Commissioning as a stand-alone remedy for system performance generally begins with the qualification and selection of a commissioning agent and an examination of current building performance. In some cases, instituting commissioning early in the overall program may eliminate the need for some retrofit measures. For example, whereas an energy analysis might indicate the need for a more efficient cooling system, a good commissioning agent might be able to solve the problem by simply balancing the thermal distribution system.

Under the various approaches, commissioning can include all or a subset of the following components:

- Establishing expected outcomes, such as how the building should perform, what the occupants need, and how much it costs
- Updating the design intent for the building so that the occupants' present needs are recognized
- Making decisions about upgrades and modifications that would cost-effectively meet the building owner's and occupants' needs
- Measuring the basic functional, energy efficiency, and thermal/environmental performance of the building's existing automatic control, heating, air conditioning, refrigeration, lighting, and other important energy systems
- Testing all building equipment to make sure it works well, works together, and actually meets the present design intent and operational specifications
- Providing building system documentation for future operations and maintenance, so that the building will continue to perform reliably and reap the expected savings
- Verifying that building and system operators have received appropriate training

Rebuild America encourages its partners to incorporate at least the last three of these components in their local retrofit programs.

Selecting a Commissioning Agent. A commissioning agent is important to successful commissioning. The individual should have expertise in design, supervision of system

installation, equipment testing, training, and development of operations manuals. Good candidates for commissioning agents will also have a working knowledge of local building codes, hands-on operation, energy conservation, indoor air quality, and construction practices. The individual should also be familiar with the design, construction, and functional processes; the functional systems involved in the specific building or buildings under consideration; and the key members of the renovation team. A commissioning agent can be an independent third-party professional engineer, design professional, or a qualified member of the team.

6 Operation and Maintenance

Many factors can cause buildings to function improperly, but good operating and maintenance procedures can reduce or eliminate the effects of these factors and maintain a high quality of building operation over time. Operation refers to activities such as the scheduling of equipment operation and temperature control. Maintenance involves caring for equipment so that it will run well for at least the duration of its expected service life. Together, operation and maintenance are the process of sustaining the performance of a building in accordance with present design requirements and intent.

Building O&M may be complex or straightforward, depending on the function of the facility and the complexity of its systems. Key components of effective operation and maintenance include a well-trained staff, adequate documentation of mechanical and electrical equipment and procedures, and good maintenance management practices.

O&M activities can be characterized as reactive (responding to emergencies and fixing equipment that breaks down), preventive (scheduling work to generate the longest-term, most energy-efficient service from a system of integrated equipment), or predictive/productive (optimizing use of resources, energy, and equipment to reap greater system savings than the equipment alone is expected to provide). The highest maintenance costs are incurred during emergencies and other reactive maintenance activities, whereas preventive maintenance reduces the risk of crisis breakdowns and the attendant costs. Overall, a good O&M program will maintain the quality of building operation.

O&M Impacts on Energy Use. Building energy use can be substantially lowered by good O&M practices such as scheduling building equipment off when not needed and by reducing the use of equipment whenever possible. Analyzing the energy use of a building, as described in Chapter 3, is also an integral part of good energy system operation. Analysis of energy use is important for determining whether energy use and costs are becoming unreasonably high, and may be useful in identifying opportunities for more efficient operation.

Case Studies in Operation and Maintenance

Project 1. The United Unions building in Washington, D.C., was studied to examine the energy benefits from multiple retrofits installed during 1987 and 1988 (McLain 1994). The 170,000-square-foot building is all electric and used about 38 kWh per square foot each year before retrofit. One of the retrofit measures had included the installation of automated controls to turn off heating and cooling equipment when not in use. This measure had been expected to save 14 kWh per square foot each year. A detailed analysis of the building energy systems and energy use showed that the building operators had already been shutting down the fans and heating/cooling systems at night and on weekends prior to the retrofit. In other words, the good O&M practices performed manually before the retrofit (although not recognized earlier) had already been saving almost $50,000 per year, even with an electric schedule that favored use of electricity during the periods when the building was unoccupied.

Project 2. While monitoring the savings from new, energy-efficient lighting equipment at a number of schools in north Texas, the school-district O&M staff noticed that the energy savings were not as high as expected. There was evidence that the HVAC systems, which were controlled by energy management control systems, might be running at night. Although the district energy manager verified that the EMCSs were programmed to be off at night, further investigation revealed that the EMCSs had been disabled in many of the schools. A contractor was hired to refurbish the EMCSs at 104 schools in the district, and the electrical energy savings are expected to total $1.5 million per year a low-cost/no-cost, back-to-basics O&M program with four main components:

- A "champion" to push the program
- Management commitment and participation
- Monthly team meetings
- Implementation (of projects), review (of results), and tabulation (of savings)

The first "blueprint" of the program included a list of 100 low-cost/no-cost energy-saving ideas to consider at every site. One unique feature of the program is the involvement of the security staff in identifying energy-saving opportunities as they make their nightly rounds. From 1992 through 1994, the program produced more than $2 million in savings each year (Owens 1994).

Poor maintenance eventually has adverse impacts on building performance, but the net effects on energy use are not easily predictable. Sometimes poor maintenance will increase building energy costs dramatically, while in other cases it may lower energy costs—but at the expense of a good indoor environment. Sometimes the resulting increases and decreases in energy use cancel each other out, yet indoor space conditions are compromised.

Building Codes and Regulations

Each state or local government jurisdiction may be considered unique both in terms of the building codes and regulations that it has adopted and in the way it enforces them. The best way to ensure compliance with codes is to consult an experienced local architect, engineer, builder, or renovator with knowledge of the applicable codes for your community. Depending upon the composition of your partnership, you may have direct access to a local building code official. In any case, you will want to make sure your local government building code agency is contacted early in the planning stage of any renovation. Accommodating such codes late in the planning stage or during design and construction can cost you money and time in the long run. The staff of the building code agency can help you identify the drawings, documentation, forms, and inspections that are required.

This section highlights building code issues that may affect your energy retrofit program. The various code categories are described briefly, and some of the codes that specifically promote energy efficiency are identified.

Code Categories

Codes and regulations for building construction and renovation are frequently divided into categories that correspond to the components of a building. Some jurisdictions have comprehensive building codes that cover all of these categories in one document; other jurisdictions may have multiple code documents, each covering an individual building system. The major categories of building codes are as follows:

- General building codes cover planning and structural requirements. They may also include special occupancy and fire protection requirements.
- Mechanical codes cover the installation (and operation) of mechanical systems such as the heating, ventilation, and air-conditioning systems. Indoor air quality requirements are often included in these codes.
- Plumbing codes cover the installation of plumbing equipment, appliances, fixtures, fittings, and piping.
- Electrical codes cover the installation of electrical systems, equipment, appliances, fixtures, and wiring.
- Energy codes cover energy performance requirements such as insulation levels, glazing types, air infiltration levels, and equipment efficiency (see next section).
- Gas codes cover the installation of fuel-gas piping and gas appliances.
- Fire prevention codes cover requirements for reasonable protection of life and property from the hazards of fire during the use and occupancy of a building.
- Life safety codes may supplement fire prevention codes.
- Accessibility codes specify building features to ensure access by physically disabled people.

Renovation of an existing building could easily be covered by several of these categories. For example, a boiler replacement could be affected by (1) general codes, to cover widening of an outside door to accommodate removal of the old boiler; (2) mechanical codes, to cover the new boiler; (3) plumbing codes, to cover the water piping; (4) electrical codes, to cover the pumps, etc.; (5) energy codes, to cover boiler performance; (6) gas codes, to cover natural gas piping; and (7) fire codes, to cover proximity to flammable walls.

Energy-Related Codes

Partnerships in those states that have not yet adopted or exceeded the MEC or ASHRAE codes may wish to use those standards for their retrofit programs.

Since Rebuild America partners will be performing energy retrofits on commercial and multifamily buildings, energy-related codes are of particular interest. These codes stipulate minimum energy performance standards for a building and its components. Depending upon the jurisdiction, these codes can span nearly all of the categories listed above. Many state and local jurisdictions have adopted nationally recognized standards known as model energy codes. These are discussed below along with the types of assistance available regarding energy standards.

Model Energy Codes. The national Energy Policy Act (EPAct) of 1992 requires all states to review and update their commercial building energy codes and, where appropriate, update their residential building codes. Based on EPAct, existing national voluntary programs, and prior state/local initiatives, an increasing number of states have adopted energy codes that meet or exceed the nationally required building standards. These minimum standards are the Council of American Building Official's (CABO's) 1992 Model Energy Code (MEC) for residential buildings and ASHRAE/IESNA Standard 90.1-1989 for commercial buildings. (Note that multifamily buildings over three stories tall are often considered to be commercial buildings.)

The widely adopted Building Officials and Code Administrator's (BOCA's) National Building Code includes a National Energy Conservation Code (NECC). The NECC requires commercial and residential buildings to comply with various ASHRAE energy standards or the CABO MEC, as applicable.

State and local governments are continually updating their energy codes. Some states have either adopted more stringent model energy codes (including the recent 1995 MEC) or developed their own (e.g., California's Title 24 residential building standards). Many states also go by ASHRAE Standard 62-89, which covers the indoor air quality of commercial and certain multifamily buildings.

Partnerships in those states that have not yet adopted or exceeded the MEC or ASHRAE codes described above may still wish to use those standards for their programs. This approach should provide further assurance of energy savings.

Energy Standards Assistance. Many state and local governments offer some form of assistance in understanding their energy codes. This support can come in a variety of forms including:

- Training and workshops
- Educational materials
- Newsletters
- Hotlines
- Compliance computer software

Benefits of Energy Standards

Building energy codes offer several benefits to your partnership and building owners. For example, energy codes help increase the energy efficiency of buildings and improve indoor air quality as well. Buildings that comply with today's widely adopted energy codes will use 20 to 30 percent less energy than non-regulated buildings. Energy standards also provide the basis for communities to meet the energy efficiency provisions for multifamily housing under certain funding and loan programs of the U.S. Department of Housing and Urban Development.

Source: U.S. Department of Energy.

Consult your local building code agencies for information on such assistance. DOE also offers a Building Standards and Guidelines Hotline at 1-800-270-CODE (2633); the staff can help you obtain descriptions of the standards mentioned in this section. The ASHRAE standards can be obtained from:

ASHRAE Customer Service
1791 Tullie Circle, NE
Atlanta, GA 30329
Phone: (800) 5-ASHRAE (274723)
FAX: (404) 321-5478

References

BPA. 1994. *Commissioning of Energy-Efficiency Measures: Costs and Benefits for 16 Buildings.* Draft report prepared for the Bonneville Power Administration.

Claridge, et al. 1994. Can You Achieve 150% of Predicted Retrofit Savings? Is It Time for Recommissioning? *Proceedings of the ACEEE 1994 Summer Study on Energy Efficient Buildings. Volume 5: Commissioning, Operation and Maintenance.*

EPA. 1995. Program Information Packet on Energy Star Buildings. *Energy Star Showcase: Montgomery County Government, A Case Study in Profitable Pollution Prevention.* Brochure of the Environmental Protection Agency.

Herzog. 1995. Commissioning Existing Buildings to Achieve Energy Efficient Operation: Four Case Studies, *Proceedings of the Third National Conference on Building Commissioning.* Portland Energy Conservation, Inc.

McLain. 1994. *Analysis of Savings Due to Multiple Retrofits in a Large Office Building.* Oak Ridge, TN: Oak Ridge National Laboratory, ORNL/CON-363.

Owens, G.R. 1994. The Energy Task Force: The Rouse Company's O&M Energy Project - A Case Study. *Proceedings of the Second National Conference on Building Commissioning,* Session 12. Portland, OR: Portland Energy Conservation, Inc.

How to Verify and Report Results

An important yardstick for measuring the success of your energy efficiency program is the amount of energy saved. Methodically verifying and documenting your energy savings will enhance the credibility of your program with local agencies, government offices, and other organizations in your community. When systematically reported to Rebuild America, your results will also contribute to the success of similar community programs around the country. This chapter provides instructions for reporting your progress and energy savings to Rebuild America and also describes several voluntary reporting opportunities that can benefit both your community and the nation.

Verifying Results

Credible results begin with the collection of energy use data prior to building retrofit, but also depend on consistent data collection efforts thereafter. You and your partners should decide upon the method or combination of methods to be used for collecting and verifying such data on an ongoing basis. Your partnership will most likely wish to engage the services of expert consultants in this area.

As discussed in Chapter 2, utility bills alone can provide a sufficient basis for determining energy savings over time. In addition to collecting utility data, however, you may wish to monitor energy use and related factors on site. On-site monitoring allows you to verify energy performance for specific equipment, by end use, or for a building as a whole. While often costly, monitoring is usually the most accurate way to determine energy savings and other program benefits. Various approaches to monitoring are discussed in Appendix B of this handbook.

An alternative approach for verifying results is to conduct evaluation studies using a control group. Under this approach, the energy use of retrofitted buildings is compared with that of non-retrofitted buildings of similar type and function. This approach helps eliminate from the analysis any changes in energy consumption that are not retrofit-related (e.g., increased computer use or extreme weather conditions). Unfortunately, evaluation studies and the use

of control groups can become quite expensive. For more information on evaluation methodologies, there are guides and handbooks that go into greater detail on the subject (e.g., ORNL 1991 and EPRI 1991).

A more formal approach for determining your energy savings is presented later in this chapter under the subheading "EPA Conservation Verification Protocols." These protocols, which were developed for the voluntary reporting of emissions reductions to the Environmental Protection Agency, define accepted methods for monitoring energy use and for estimating "stipulated" energy savings (used only with certain retrofit technologies that have well-established energy impacts).

Regardless of the method or methods used to ascertain energy savings and other program benefits, your partnership should develop a reasonable plan for collecting and analyzing building data on an ongoing basis. Such a plan can be simple or complex, but your partnership should decide how post-retrofit energy use data is to be compiled and how that data will be compared to the pre-retrofit or "baseline" data. You may decide to use a variation on an established approach or a combination of approaches. You and your partners will also need to specify the areas of expertise necessary to implement the particular data collection and verification plan you have devised. The skills required are likely to be similar to those of the energy analyst (described in Chapter 2) and the energy auditor (described in Chapter 6). These skills include the following:

- Knowledge of building energy retrofits
- Building energy data collection skills
- Monitoring (or metering) of building energy use, if applicable
- Building energy and cost analysis expertise
- Energy savings evaluation experience
- Reporting and computer skills

Your data collection and analysis plan should also contain provisions for reporting your results to Rebuild America and, if applicable, to community groups and local government agencies.

Reporting to Rebuild America

To measure the effectiveness of the Rebuild America program as a whole and to assist future energy efficiency retrofit programs, all active partnerships are asked to submit brief progress reports to Rebuild America. These progress reports highlight the milestones achieved by your

partnership, including program status information and energy-related data for individual buildings. Reports should be submitted to Rebuild America every January and July.

To facilitate your report preparation and submission, Rebuild America offers several guidelines for report content and format, but partnerships are not bound by these guidelines. You are encouraged to customize your reports to minimize the effort necessary to produce them for Rebuild America. For example, if you are already producing a similar report for your local community or government agency, you may wish to simply adapt it as needed for submission to Rebuild America. Similarly, you may decide to report post-retrofit energy use data in a form that is more compatible with the way in which the data is collected and analyzed (e.g., by group of buildings as opposed to individual buildings). Although Rebuild America is flexible with regard to reporting, you should consult your program representative to discuss any alternative reporting formats. Once a format is selected, you will need to be consistent in using that format for subsequent report submittals.

If your partnership is currently receiving financial assistance from the Rebuild America program, you are not required to submit the progress reports described above. As part of your cooperative agreement, you will be completing a form entitled, Federal Assistance Program/Project Status Report, Form F 4600.6, which satisfies the reporting requirement.

Program Status Information

The program status portion of your progress report may be in narrative or tabular format and need not be longer than one or two pages. The information included should represent the highlights of your program and enable Rebuild America to track your progress. The types of program status elements that should be included are shown in the box on the following page.

Rebuild America is anxious to learn about your local program. Please feel free to include any additional information that you think would be of interest to the program or helpful to other community partnerships.

Energy-Related Data

The energy data you report will enable Rebuild America to measure total energy savings for your program and the combined impact of similar programs on a national scale. To put energy savings in perspective, Rebuild America needs to know the square footage of commercial buildings and the number of dwelling units in multifamily buildings where retrofits have been performed. All of these data elements are items that you should already be collecting and analyzing as part of your local program.

Partnerships are asked to present results data by individual building. If reporting by individual building is not feasible for

Reports should be submitted to Rebuild America every January and July.

Progress Report Elements

Program Status

- Partnership name
- Contact person name, title, address, phone number, and facsimile number
- Any new members to your partnership
- Number, type, and status of buildings selected (commercial or multifamily, and whether buildings are under renovation, completed, and so forth)
- Brief description of retrofits performed in each building (including fuel switching)
- Total dollars invested in retrofits
- General status of program funding
- Plans for the next 6 to 12 months
- Program success stories (concerning particular buildings, marketing campaigns, results verification approaches, etc.), if any
- Jobs created, local economic benefits achieved, value of capital investments made, and other similar program benefits, if available
- Problems encountered, relevant issues, and solutions, if any

You may contact your program representative to establish an alternative reporting format.

Energy-Related Data
(when available)

- A description of the building, including:
  - Name, number, or other identifier
  - Type of building (commercial or multifamily)
  - Principal building activity (office, education, etc.), if commercial building
  - Total floor area for commercial buildings and type of floor area measurement (gross, net rentable, net usable, etc.) or
  - Total number of dwelling units for multifamily residential buildings (and square footage of a typical unit, if available)
- Baseline and post-retrofit data, including:
  - Total monthly energy use for electricity (kBtu)
  - Total monthly energy use for fuels other than electricity (kBtu)
  - Total monthly cost for electricity
  - Total monthly cost for other fuels
  - Start and end dates of time periods reported

your program and you have a more effective method, you may contact your program representative to establish an alternative reporting format. For example, one alternative approach is to group buildings that share a single utility meter or that were retrofitted in the same calendar or fiscal year. If you wish to provide aggregate data in addition to data by individual building, you are encouraged to do so.

The reporting requirements are straightforward; you are asked to provide the energy-related data elements shown in the box on the previous page for each individual building They may be presented in tabular or other summary formats.

The type of floor area measurement should remain consistent between your baseline and post-retrofit data sets. In addition, care should be taken to report energy use for a consistent amount of commercial square footage or number of multifamily dwelling units in each building from year to year. The square footage or number of units reported should be identical in both the baseline and post-retrofit cases. If significant changes occur in a building over time, please provide the specifics (e.g., amount of increased floor area, change in principal building activity, etc.) to Rebuild America.

Entering the correct amount of square footage and number of dwelling units in your reports to Rebuild America is critically important. As a general rule, you should simply report the number of units actually retrofitted within each multifamily building. Keep in mind that the replacement of a central boiler in an apartment building serves as a retrofit to all of the units served by that boiler. Of course, if the energy use for all of the units in a building is recorded through one central meter, then you should include all of those units in your total count (regardless of how many of those units were actually retrofitted). The obvious exception would be if you decide to separately monitor the energy use (over time) for just the retrofitted units.

The same guidelines apply to commercial building floorspace; you should report only the retrofitted square footage in a building, provided that it is metered separately by the utilities or monitored by your partnership. You may also elect to disaggregate a building's total metered energy use if you employ defensible calculations.

In addition to the energy-related data elements listed in the box, any other results generated by your partnership are of interest to Rebuild America. Such results may be submitted in summary form along with an explanation of the methodology and assumptions you used and references to any relevant documents. In particular, Rebuild America would like to see the following types of results if you develop them, as they would prove valuable in compiling the nationwide benefits of the Rebuild America program:

- Energy use data adjusted over time using local or regional weather data
- Reductions in electricity demand
- Reductions in air emissions

Report Format

Any narrative portion of your progress report can be submitted on paper or in an acceptable electronic format, or both. The format preferred by Rebuild America for reporting energy-related data is an IBM PC-compatible electronic spreadsheet. Variations on this format are acceptable (such as database formats) as long as all data elements are present and clearly identified. Data can be submitted on diskette or by electronic mail.

For data formats deviating from those suggested above, consult your Rebuild America program representative to arrange alternative reporting of files. In such cases, you may be asked to submit certain file attributes and format specifications. Your representative will also provide you with any necessary updates with regard to reporting forms or formats as well as information on where to submit your reports.

Reporting to Additional Organizations

Partners may benefit from reporting their results to additional sources. For example, reductions in air emissions (based on decreases in fuel use) can be reported to both the Energy Information Administration (EIA) of DOE and the Environmental Protection Agency (EPA). Reports to EIA are discussed below. The EPA reports require a separate verification protocol, which is discussed briefly below.

Voluntary Emissions Reporting to EIA

DOE's Energy Information Administration (EIA) has developed a voluntary reporting program for reporting reductions in greenhouse gas emissions and carbon sequestration as required by Section 1605(b) of the National Energy Policy Act (EPAct) of 1992. There are several reasons your partnership may wish to report emissions to EIA, including

- To gain partnership and community recognition for environmental stewardship efforts
- To establish a public record of emissions and reductions that may be referenced in the future

- To demonstrate support for voluntary approaches to achieving environmental policy goals
- To promote information exchange on the most effective ways to reduce emissions of greenhouse gases
- To inform public debate about activities aimed at achieving reductions in greenhouse gases
- To demonstrate progress toward meeting previous voluntary commitments to reduce emissions of greenhouse gases

Specific guidelines have been developed for estimating emissions and analyzing emissions-reducing and carbon-sequestering projects. The guidelines address four major greenhouse gases: carbon dioxide, methane, nitrous oxide, and halogenated substances. Although other gases are not generally discussed, you can also report nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOCs), and carbon monoxide (CO).

EIA has designed this voluntary reporting program to be flexible and easy to use. For example, you are encouraged to use the fuel-consumption or energy-savings data that you may have already compiled for other programs or for your own internal tracking. In addition, you may use the default emissions factors and stipulated factors developed by EIA for some other types of projects to convert your existing data directly into estimated emissions reductions. The intent is to simplify the reporting process, not to discourage you from developing your own emissions estimates.

Whether your reports cover your entire organization, one project, or some level in between, you can obtain guidance on analyzing your projects and developing your reports by contacting EIA. A variety of communication avenues are available: call at 1-800-803-5182, connect through Internet at http://www.eia.doe.gov/oiaf/1605/frntend.html, or write to the address below:

Voluntary Reporting of Greenhouse Gases Program
Energy Information Administration, EI-81
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

EPA Conservation Verification Protocols

Two protocols were developed by the Environmental Protection Agency (EPA) to assist utilities in verifying energy use data and, ultimately, air emissions reductions. EPA developed the protocols to implement the Acid Rain Program of the Clean Air Act Amendments of 1990 (EPA 1993). Although these protocols were originally developed for utilities, the same concepts may be applied to individual

buildings or groups of buildings at a specific location. If you are working with a utility in your partnership, some regional benefits may be available from such reporting.

The two protocols are known as Monitored Energy Use, which is the preferred approach, and Stipulated Savings. One objective of the monitored energy use protocol is to measure energy consumption to determine net energy savings (that is, the savings attributable to an energy efficiency program). The stipulated savings approach uses simple equations and standard values for estimating energy savings associated with specific retrofit measures, and can therefore be used only with certain measures. Both protocols include guidelines for verifying the persistence of energy savings.

Monitored Energy Use. This approach requires that several key activities be accomplished before the process is useful. Those activities include

- Specifying a reference case
- Adjusting for differences in such variables as weather, operating hours, and number of occupants
- Determining net energy savings
- Establishing an appropriate level of statistical confidence in the savings

(The most important feature of this approach is the establishment of a reference case so that net savings can be determined. Note that this reference case or baseline data should correspond as closely as possible to the specific buildings included in the retrofit. Ideally, monitoring will continue both before and after the energy efficiency measures are implemented in your buildings. Various approaches to monitoring and monitoring protocols are discussed in Appendix B.)

Stipulated Savings. For a limited number of well-understood technologies, simple algorithms can be used to estimate energy savings. The technologies include constant-load motors, exit-sign lights, amorphous metal transformers, commercial lighting, new refrigerators, street lights, and water heater insulation blankets. The stipulated savings approach is especially advantageous for new retrofit programs with limited funds or when monitored energy use is not cost effective. In either case, however, the performance of measures must already be well documented. For further information on these verification protocols, you are encouraged to consult the appropriate EPA publications (EPA 1993, 1995).

References

EPA. 1995. *Conservation Verification Protocols.* Washington, DC: U.S. Environmental Protection Agency,

EPA 430/B-95-012. (Available through EPA's Acid Rain Hotline at 202-223-9620.)

EPA. 1993. *The User's Guide to the Conservation Verification Protocols.* Washington, DC: U.S. Environmental Protection Agency, EPA 430/B-93-002. (Updated publication expected in January 1996. Available through EPA's Acid Rain Hotline at 202-223-9620.)

EPRI. 1991. *Impact Evaluation of Demand-Side Management Programs, Volume 1: A Guide to Current Practice.* Electric Power Research Institute, EPRI CU-7179, V1. (Available through EPRI's Distribution Center at 510-934-4212.)

ORNL. 1991. *Handbook of Evaluation of Utility DSM Programs*, edited by Eric Hirst and John Reed, Oak Ridge National Laboratory, ORNL/CON-336. (Available through the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161, 703-487-4650.)

Appendix A:

Unit Conversions

From	To	Multiply by
kWh	Btu	3,413
kBtu	Btu	1,000
MBtu	Btu	1,000,000
SCF of Natural Gas	Btu	1,030
CCF of Natural Gas	Btu	103,000
Therm	Btu	100,000
Gallons of Fuel Oil #2	Btu	138,690
Gallons of Fuel Oil #6	Btu	149,690
Short Tons of Coal	Btu	23,105,000
Gallons of Propane	Btu	91,333
Pounds of Purchased Steam	Btu	1,150

Note: Use actual local values if known.

Sources: EIA, *Annual Energy Outlook 1995*, Appendix I, Table I1, p. 173 for natural gas, fuel oil, and coal conversions; *Annual Energy Review 1994*, Appendix A, Table A1, p. 345 for propane conversion.

Appendix B:

Monitoring

Partners in the Rebuild America program can use monitoring to diagnose specific energy-related problems in buildings, to verify short-term retrofit savings, and to assess long-term program benefits. Energy use monitoring of buildings or building systems can be performed before a retrofit to establish a reference or base case, to identify energy-saving opportunities, or to aid post-retrofit analysis. Post-retrofit monitoring alone is often useful if the prior energy performance of an improved or replaced system is well understood. This section describes typical monitoring approaches and discusses monitoring protocols.

Approaches to Monitoring

Most building energy monitoring or metering efforts fall into one of four categories:

- Whole Building Energy Use Monitoring
- Energy End-Use Monitoring
- Technology Assessments
- Building or System Diagnostics

Whole building energy use monitoring studies generally analyze utility meter data for the whole building and generate indices on energy and power use that can be compared across a group of buildings. The types of analyses that might be performed include using energy indices to identify buildings that consume large amounts of energy and may be candidates for improvements, evaluating energy efficiency programs using data from many buildings, or using detailed hourly data to determine average power profiles for a group of buildings. In some cases, metering of separate buildings within a facility or of individual activities within a building is desirable.

Energy end-use monitoring studies for commercial buildings differ from whole building studies by requiring measurements of energy flows and/or power levels in the building at a sufficient level of detail to break down the data according to use (e.g., heating, cooling, lighting, fans, elevators, or "other", depending on the end uses of interest). The timeframe for monitoring is often set at one year in order to obtain data for the different end uses during each season.

Technology assessments are directed at measuring the field performance of a building system, retrofit measure, or other technology in individual buildings. The timeframe depends on the monitoring methods; it can be as short as two weeks or as long as a year. It is usually of interest to characterize any variations observed in the

performance of the different systems (or of different buildings). Detailed supporting data on laboratory performance or from on-site surveys are often incorporated in these studies.

Diagnostic studies of buildings or systems are generally of short duration, with monitoring focused on answering specific questions related to energy use, power levels, or other performance parameters associated with specific buildings, building systems, or technologies.

You will typically want to find good technical support in this area, and the team that oversees the energy audits may also be able to help define and select the type of monitoring support needed. This is an area in which DOE offers strong technical support to its Rebuild America partners.

Monitoring Protocols

There are several monitoring protocols that have been developed by professional societies over the past several years. Many of these are discussed in the *Standard Guide for Developing Energy Monitoring Protocols for Commercial and Institutional Buildings or Facilities* (ASTM 1991) and *Building Energy Monitoring* (ASHRAE 1995). These protocols are based on the "lessons learned" from a variety of large, end-use load-monitoring projects that were conducted during the 1980s (EPRI 1986, Gillman et al. 1989, MacDonald et al. 1989, Acherman 1990, Martinez and Powers 1990, and Kasmar et al. 1990).

The basic elements of a successful monitoring program can be broken down into nine steps, as listed below (ASHRAE 1995).

1. Identify project goals, objectives, and research questions.
2. Specify data products and output.
3. Specify approach to experimental design.
4. Specify procedures and algorithms for data analysis.
5. Specify monitoring points of field data.
6. Specify building characteristics.
7. Resolve concerns regarding accuracy of data.
8. Specify procedures for verification and quality control.
9. Specify formats for recording and reporting data.

The exact nature and level of detail appropriate for any one step is dependent on the number of buildings to be considered. Typically, an iterative approach is taken to implement these steps, based on anticipated costs and the available resources.

References

Acherman, J. 1990. End-Use Metering: A Demand-Side Program and More. Proceedings of the Second Annual Conference on End-Use Load Information and Its Role in DSM. Irvine, CA, July 11-13, 1990.

ASHRAE. 1995. *1995 HVAC Applications Handbook.* Atlanta, GA: American Society of Heating, Refrigerating and Air Conditioning Engineers, Chapter 37.

ASTM. 1991. Standard Guide for Developing Energy Monitoring Protocols for Commercial and Institutional Buildings or Facilities. *1991 Annual Book of ASTM Standards - Volume 04.07.* Philadelphia, PA: American Society for Testing and Materials, E1464-92.

EPRI. 1986. *Commercial End-Use Metering Workshop.* Palo Alto, CA: Electric Power Research Institute, EPRI EM-4393.

Haberl, J.S., et al. 1996. *Measuring Energy-Saving Retrofits: Experiences from the Texas LoanSTAR Program.* Oak Ridge National Laboratory, ORNL/Sub/93-SP090/1.

Kasmar J. and M. Fishbaugher. 1990. Implementation Experiences and Preliminary Results from Pacific Gas and Electric Company's Commercial End-Use Metering Project. *Proceedings of the Second Annual Conference on End-Use Load Information and its Role in DSM.* Irvine, CA, July 11-13.

MacDonald, J.M., T.R. Sharp, M.B. Gettings. 1989. *A Protocol for Monitoring Energy Efficiency Improvements in Commercial and Related Buildings.* Oak Ridge, TN: Oak Ridge National Laboratory, ORNL/CON-291.

Martinez M.S. and J. Powers. 1990. Expanding a Residential End-Use Metering Project to Meet Revised Planning Objectives. *Proceedings of the Second Annual Conference on End-Use Load Information and its Role in DSM.* Irvine, CA, July 11-13.

List of Acronyms

ACEC	American Consulting Engineers Council
ACEEE	American Council for an Energy Efficient Economy
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BECA	*Building Energy and Compilation Analysis* (database)
BNL	Brookhaven National Laboratory
BOCA	Building Officials and Code Administrators
BPA	Bonneville Power Administration
CABO	Council of American Code Officials
CBECS	EIA's *Commercial Buildings Energy Consumption Survey*
CFC	Chlorofluorocarbon
CO	Carbon monoxide
COP	Coefficient of performance
CVP	Conservation verification protocols
DHC	District heating and cooling
DOE	U.S. Department of Energy
DSM	Demand-side management
EEI	Edison Electric Institute
EER	Energy efficiency ratio
EIA	Energy Information Agency (DOE)
ELCAP	End-Use Load Conservation Assessment Program
ELF	Electrical load factor
EMCS	Energy management control systems
EMS	Energy management system
EOLF	Electrical occupancy load factor
EPA	U.S. Environmental Protection Agency
EPAct	Energy Policy Act of 1992
EPRI	Electric Power Research Institute
EREC	Energy Efficiency and Renewable Energy Clearinghouse
ESCo	Energy service company
EUI	Energy use index
FCA	Fuel cost adjustment
HUD	U.S. Department of Housing and Urban Development
HVAC	Heating, ventilating, and air conditioning
IAQ	Indoor air quality
ICP	Institutional Conservation Program
IESNA	Illuminating Engineering Society of North America
LCC	Life cycle cost
LBNL	Lawrence Berkeley National Laboratory (formerly Lawrence Berkeley Laboratory)
MEC	Model Energy Code (CABO's)
NBS	National Bureau of Standards (since renamed the National Institute of Standards and Technology)

NECA	National Electrical Contractors Association
NECC	National Energy Conservation Code (BOCA's)
NMVOCs	Nonmethane volatile organic compounds
NTIS	National Technical Information Service
O&M	Operations and maintenance
ORNL	Oak Ridge National Laboratory
OSTI	Office of Scientific and Technical Information
PCB	Polychlorinated biphenyl
PNNL	Pacific Northwest National Laboratory (formerly Pacific Northwest Laboratory)
RECS	EIA's *Residential Energy Consumption Survey*
SECP	State Energy Conservation Program

List of Units

Btu	British thermal unit (refer to Appendix A)
CCF	Hundred cubic feet (of gas)
kBtu	Thousand Btus
kVA	kilo-volt amperes
kW	Kilowatts
kWh	Kilowatt-hours
MBtu	Million Btus
Quad	Quadrillion British thermal units
SCF	Standard cubic feet
Therm	Hundred-thousand Btus
W	Watts

For technical assistance or additional information, contact your regional Rebuild America Program Representative. General questions regarding the program should be directed to:

Energy Efficiency and Renewable Energy Clearinghouse
(EREC)

P.O. Box 3048
Merrifield, VA 22116
Phone: 1-800-DOE-EREC (363-3732)
Internet: ENERGYINFO@delphi.com
TDD: 1-800-273-2957